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ABSTRACT

This curriculum guide is intended to assist persons teaching a course in repairing two- and four-stroke cycle small engines. Addressed in the individual units of instruction are the following topics: safety, tools, fasteners, and measurement techniques; basic small engine theory (engine identification and inspection, basic engine principles and design, and operation principles of two- and four-stroke engines); electrical systems (basic electricity and ignition, charging, and starting systems); and engine service (parts management; lubrication, cooling, fuel, governor, and exhaust systems; troubleshooting; and overhaul of four- and two-stroke cycle engines). Each unit contains some or all of the following: performance objectives, suggested activities for teachers and students, information sheets, transparency masters, assignment sheets, job sheets, tests, and answers to the tests. (MN)

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SMALL ENGINE REPAIR

Two-Stroke and Four-Stroke Cycle

(Revised Edition of *Comprehensive Small Engine Repair*)

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SMALL ENGINE REPAIR

Two-Stroke and Four-Stroke Cycle

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FOREWORD

The Mid-America Vocational Curriculum Consortium (MAVCC) was organized for the purpose of developing instructional materials for its eleven member states. Priorities for developing MAVCC materials are determined annually based on the needs as identified by all member states. One of the priorities identified was the revision of *Comprehensive Small Engine Repair.*

The success of this publication is due, in large part, to the capabilities of the personnel who worked with its original development and revision. The technical writers have numerous years of industry as well as teaching experience. Assisting them in their efforts were representatives of each of the member states who brought with them technical expertise and the experience related to the classroom and to the trade. To assure that the materials would parallel the industry environment and be accepted as a transportable basic teaching tool, organizations and industry representatives were involved in the developmental phases of the manual. Appreciation is extended to them for their valuable contributions to the manual.

This publication is designed to assist teachers in improving instruction. As it is used, it is hoped that student performances will improve and that students will be better able to assume a role in their chosen occupation, small engine repair.

Instructional materials in this publication are written in terms of student performance using measurable objectives. This is an innovative approach to teaching that accents and augments the teaching/learning process. Criterion referenced evaluation instruments are provided for uniform measurement of student progress. In addition to evaluating recall information, teachers are encouraged to evaluate the other areas including process and product as indicated at the end of each instructional unit.

It is the sincere belief of the MAVCC personnel and all those members who served on the committees that this publication will allow students to become better prepared and more effective members of the work force.

James Dasher, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

PREFACE

If one stops to think about the many and varied uses of some type of small engine, it is easy to understand why educators have felt the need for instructional materials to improve the quality of their training programs. It is not so much that there is a shortage of materials available, but that there are so many that no single instructor has the time to compile them for use. To this task, the Mid-America Vocational Curriculum Consortium developed the original *Comprehensive Small Engine Repair* manual which was released in 1977.

Utilization of these units of instruction has far exceeded anything which we had anticipated. Therefore, it seemed only natural that we should look at it on a regular basis in order to provide the book with the technical update needed to keep the user current. The result of this work is the revised publication, *Small Engine Repair: Two-Stroke and Four-Stroke Cycle.*

Be assured that teachers, industry representatives, and various others have been involved to make this publication usable, readable, and by all means basic enough to be easily used. It is hoped that once you have used these materials which address the information needed to be able to repair most two and four cycle engines, you will consider the various supplements which MAVCC has also developed. They include:

Outdoor Power Equipment Repair
Chain Saw Repair
Motorcycle Repair
Outboard Repair
Snowmobile Repair

Because we wish to continue the process of updating and revising, we invite you to notify us of any suggestions and/or corrections which you feel would increase the quality of this publication. A postage paid postcard has been enclosed for this purpose.

Best wishes for the successful use of *Small Engine Repair.*

Greg Pierce
Executive Director
Mid-America Vocational
Curriculum Consortium, Inc.

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ACKNOWLEDGEMENTS

Appreciation is extended to those individuals who contributed their time and talent to the development and revision of *Comprehensive Small Engine Repair.*

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Special thanks are extended to Amon Herd, Associate Director, Instructional Materials Laboratory, University of Missouri-Columbia and his staff for their contributions toward the development of this book. Special appreciation goes to Briggs and Stratton Corporation and to Dan Stapleton, graphic designer, and Paul Hughes, illustrator, with the Instructional Materials Laboratory, University of Missouri-Columbia, for the illustrations and drawings used in this publication.

Gratitude is also expressed to the businesses and industries who provided us with reference materials; to Jane Huston for her assistance in editing; to Tom Harriman and John Hanson for their assistance in checking technical content; to Kim Hale for his assistance in revising artwork; to Leslie Mathis for typing; and to the printing staff of the Oklahoma State Department of Vocational and Technical Education for printing this publication.

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USE OF THIS PUBLICATION

Instructional Units

Small Engine Repair: Two-Stroke and Four-Stroke Cycle contains twenty-one units which have been divided into four main areas of interest. Each instructional unit includes some or all of the basic components of a unit of instruction; performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the test. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help to determine:

A. The amount of material that can be covered in each class period
B. The skills which must be demonstrated

    1. Supplies needed
    2. Equipment needed
    3. Amount of practice needed
    4. Amount of class time needed for demonstrations

C. Supplementary materials such as pamphlets or filmstrips that must be ordered
D. Resource people who must be contacted

Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When teachers add objectives, they should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities for the Instructor

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. Duties of instructors will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives in the unit. The teacher will find that the information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skill specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion.

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledge which is a necessary prerequisite to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for students to follow if they have missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances which might reasonably be expected from a person who has had this training.

Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

SMALL ENGINE REPAIR

Two-Stroke and Four-Stroke Cycle

INSTRUCTIONAL/TASK ANALYSIS

SECTION A — ORIENTATION

UNIT I: SAFETY

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms and definitions
	2. Colors of the safety color code
	3. Steps for maintaining a safe and orderly shop
	4. Classes of fires
	5. Components of the fire triangle
	6. Types of fire extinguishers
	7. Safe and unsafe shop practices
	8. Consumer Product Safety Commission standards
	9. General shop safety rules
10. Complete a student safety pledge form	
11. Complete a student shop safety inspection checklist	

UNIT II: TOOLS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Basic hand tools
	2. Standard overhaul tools
	3. Types of torque wrenches
	4. Maintenance procedures for tools

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT III: FASTENERS

1. Terms and definitions
2. Qualities of satisfactory fasteners
3. Typical fasteners
4. Typical bolt head styles
5. Measuring bolts and threads
6. SAE grade and metric bolts
7. Typical nuts
8. Special purpose nuts
9. Methods used to remove a seized nut
10. Types of washers
11. Tools used to restore bolt threads
12. Tools to restore internal threads
13. Devices for locking nuts or bolts
14. Types of machine screw head designs
15. Types of snap rings
16. Repair damaged threads using a thread repair kit

UNIT IV: MEASURING

1. Terms and definitions
2. Measuring instruments

INSTRUCTIONAL/TASK ANALYSIS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	3. Steps for reading measuring instruments
	4. Basic units of measurement found on rules
	5. Major parts of vernier caliper
	6. Major parts of an outside micrometer
	7. Proper methods for checking accuracy of outside micrometers
	8. Major parts of a dial indicator
	9. Set up and use of a dial indicator
10. Read the plain micrometer settings	
11. Read the vernier micrometer settings	
12. Use a vernier caliper	
13. Use a plain micrometer	
14. Use a dial indicator	
15. Use a telescoping gauge	

SECTION B — BASIC SMALL ENGINE THEORY

UNIT I: ENGINE IDENTIFICATION AND INSPECTION

	1. Terms and definitions
	2. Characteristics of four-cycle and two-cycle engines
	3. Meaning of the model, type and code numbers found on the engine
	4. Engine information
	5. Operating positions of the crankshaft

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
6. Complete an engine information form	
7. Complete an information form on accessories and major units found on an engine	

UNIT II: BASIC ENGINE PRINCIPLES AND DESIGN

	1. Terms and definitions
	2. Characteristics of energy
	3. Types of energy
	4. Forms of available energy
	5. Types of motion
	6. Parts of basic internal combustion engine
	7. Process by which an internal combustion engine converts chemical energy into rotary motion
	8. Types of engine design
	9. Types of engine cooling systems
10. Calculate problems using the formula for work	
11. Calculate problems using the formula for horsepower	
12. Calculate problems using the formula for torque	
13. Calculate problems using the formula for engine cubic inch displacement	
14. Calculate problems using the formula for compression ratio	

INSTRUCTIONAL/TASK ANALYSIS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT III: PRINCIPLES OF OPERATION — FOUR-STROKE CYCLE

1. Terms and definitions
2. Components of a four-stroke cycle engine
3. Operation of a four-stroke cycle engine
4. Factors that determine firing order of a multi-cylinder engine
5. Camshaft lobe
6. Valve timing and overlap
7. Types of valve arrangements

UNIT IV: PRINCIPLES OF OPERATION — TWO-STROKE CYCLE

1. Terms and definitions
2. Components of a basic two-stroke cycle engine
3. Operation of a two-stroke cycle engine
4. Valves used in two-stroke cycle engines
5. Factors which determine timing on two-stroke cycle engines
6. Design variations
7. Features which make a two-stroke cycle engine preferable for many applications
8. Correct exhaust system design

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

SECTION C — ELECTRICAL SYSTEMS

UNIT I: BASIC ELECTRICITY

1. Terms and definitions
2. Sources of electricity
3. Parts of a basic circuit
4. Good conductors and insulators of electricity
5. Direct and alternating current
6. Basic electrical schematic symbols
7. Letter designations used in Ohm's law
8. Ohm's law in triangle expression
9. Ohm's law in letter formula
10. Types of electrical circuits
11. Rules for series circuits
12. Rules for parallel circuits
13. Factors affecting resistance in a conductor
14. Relationship between electricity and magnetism
15. Factors that determine the magnitude of induced voltage
16. Instruments used in checking electrical circuits
17. Solve problems using Ohm's law formula

INSTRUCTIONAL/TASK ANALYSIS

JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)

RELATED INFORMATION: What
the Worker Should Know
(Cognitive)

18. Identify basic electrical schematic symbols
19. Measure resistance using an ohmmeter
20. Check continuity
21. Use an ohmmeter to test for defective diodes
22. Measure amperage in a circuit
23. Check voltage
24. Use a digital voltohmmeter

UNIT II: IGNITION SYSTEMS

1. Purpose of the ignition system
2. Types of ignition systems
3. Components of a primary and secondary battery ignition circuit
4. Components of a magneto ignition system
5. Components of a solid state ignition system
6. Components of a breakerless ignition system
7. Components of the ignition system
8. Operational steps of the ignition systems

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
9. Remove, service, and replace spark plugs	
10. Remove and replace contact points and condenser	
11. Test the coil, condenser, armature, and flywheel magnets	
12. Test and adjust a solid state ignition system	
13. Perform a coil power test	
14. Check ignition timing using a dial indicator	
15. Test condenser for leakage or short	

UNIT III: CHARGING SYSTEMS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms and definitions
	2. Kinds of charging systems
	3. Charging system components and functions
	4. Operating stages of charging system
	5. How a generator converts AC to DC
	6. Parts of the alternator system
	7. Advantages of an alternator over a generator
	8. Reverse polarity
9. Remove and replace an alternator	
10. Disassemble, check, and reassemble an alternator	

INSTRUCTIONAL/TASK ANALYSIS

UNIT IV: STARTING SYSTEMS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms and definitions
	2. Types of small gas engine starters
	3. Components of the mechanical starting system
	4. Components of the DC starting system
5. Remove, disassemble, test, service, and reassemble a starter	
6. Replace starter rewind spring	
7. Service the vertical pull starter	

SECTION D — ENGINE SERVICE

UNIT I: PARTS MANAGEMENT

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms and definitions
	2. Types of information found in the parts catalog
	3. Common parts and their abbreviations
	4. Steps in using a parts catalog
	5. How to price parts correctly
	6. The microfiche system and how to use it
	7. Advantages of using computers in inventory control and stocking
	8. Advantages of good inventory control
	9. Guidelines for taking a physical inventory
10. Complete a service order	
11. Take a physical inventory of small engine parts	

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
UNIT II: LUBRICATION SYSTEMS	
	1. Terms and definitions
	2. Two types of lubrication systems
	3. Purpose of the crankcase breather
	4. Components of the crankcase breather
	5. Functions of engine
	6. Characteristics of a good engine oil
	7. SAE viscosity number
	8. API classification system
	9. Oil contaminants
	10. Oil additives
	11. Factual statements about oil
	12. Selection and use of oils for best engine performance
	13. Two cycle oil selection and use
14. Change engine oil and filter	
15. Service crankcase breather	
UNIT III: COOLING SYSTEMS	
	1. Terms and definitions
	2. Functions of the cooling system
	3. Components of the cooling system
	4. Causes of overheating
5. Remove, clean, and replace air cooling parts	

INSTRUCTIONAL/TASK ANALYSIS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT IV: FUEL SYSTEMS

1. Terms and definitions
2. Purpose of the fuel system
3. Basic types of small engine fuel supply systems
4. Components of the fuel system
5. Types of carburetors
6. Types of fuel filters
7. Types of fuel pump action
8. Types of air cleaners
9. Parts of the float-type carburetor
10. Parts of the diaphragm-type carburetor
11. Carburetor systems
12. Service an air cleaner
13. Remove and replace a float type carburetor
14. Service a float-type carburetor
15. Remove, service, and replace a diaphragm-type carburetor
16. Remove and replace a fuel pump
17. Test and service a fuel pump
18. Service sediment bowl fuel strainer

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT V: GOVERNOR SYSTEMS

JOB TRAINING	RELATED INFORMATION
	1. Terms and definitions
	2. Purposes of the governor system
	3. Types of governor systems
	4. Components of the governor systems and their purposes
5. Inspect, adjust and repair an air vane governor	
6. Inspect and adjust external components of a mechanical governor with internal flyweights	
7. Repair internal components of a mechanical governor with internal flyweights	

UNIT VI: EXHAUST SYSTEMS

JOB TRAINING	RELATED INFORMATION
	1. Terms and definitions
	2. Results of running a worn or damaged exhaust system
	3. Types of exhaust systems
	4. Danger of operating an engine in a closed shop
5. Remove, service, and replace two-cycle exhaust system components	

UNIT VII: TROUBLESHOOTING

JOB TRAINING	RELATED INFORMATION
	1. Definition of troubleshooting
	2. Requirements for an engine to run
	3. Basic troubleshooting procedures
	4. Importance of understanding troubleshooting procedures

INSTRUCTIONAL/TASK ANALYSIS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
5. Solve problems using the small engine troubleshooting chart	
6. Troubleshoot the fuel system	
7. Troubleshoot the ignition system	
8. Troubleshoot engine compression	
UNIT VIII: OVERHAUL FOUR-STROKE CYCLE ENGINE	
	1. Terms and definitions
	2. Causes of engine problems
	3. Parts of the piston and connecting rod assembly
	4. Parts of the crankshaft assembly
	5. Parts of a multi-piece crankshaft
	6. Parts of the valve train
7. Disassemble a four-stroke cycle engine	
8. Inspect and service a cylinder	
9. Inspect and service the piston, rings, and connecting rod	
10. Inspect and service a crankshaft and crankcase assembly	
11. Inspect and service a valve assembly	
12. Reassemble a four-stroke cycle engine	

UNIT IX: OVERHAUL TWO-STROKE CYCLE ENGINE

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Terms and definitions
	2. Causes of two-stroke cycle engine problems
	3. Parts of the two-stroke cycle piston and connecting rod assembly
	4. Parts of a two-stroke cycle crankshaft assembly
5. Disassemble, inspect, and service a two-stroke cycle engine	
6. Reassemble a two-stroke cycle engine	

SMALL ENGINE REPAIR

Two-Stroke and Four-Stroke Cycle

TOOLS, EQUIPMENT, AND MATERIALS LIST

(NOTE: These are the recommended tools, materials, and equipment necessary for a small engine repair training program.)

- Ammeter
- Armature grounder
- Assortment of
  - fractional drill bits
  - letter size drill bits
  - machined parts
- Awl

- Battery
- Bearing installation tools
- Bearing pullers

- Carbon solvent
- Carburetor cleaning fluid
- Carburetor repair kit
- Carburetor screw drivers
- Circuits
  - containing less than 1 volt
  - containing variable resistance
- Cleaning solvent
- Clipboard
- Combination square
- Compressed air
- Compression gauge
- Cylinder vise support

- Deglazing tool
- Dial indicator
- Dial indicator holder
- Diaphragm
- Digital voltmeter
- Diodes
- Drain pan
- Drill motor

- Engine oil (clean)
- Engine stand

- Feeler gauges
- Flywheel holder
- Flywheel puller
- Flywheel wrench

- Gasket (new)
- Gasket for glass bowl
- Gasket sealer
- Gasket set for engines
- Grease
- Hand sprayer (small)
- Hardwood scraper
- Hone
- Ignition wrench set

- Lathe or vise
- Light oil, 5-10 weight

- Magneto base
- Mallet

- Ohmmeter with test leads
- Oilcan spout
- Oil drain pan
- Oil seals
- Operator's manuals (as appropriate)
- Outside micrometer

- Parts cleaning basket
- Parts cleaning brush or rag
- Parts container
- Parts scraper
- Piston stop
- Plain micrometer
- Plastigauge
- Portable drill

- Recoil spring (new)
- Reject gauges
- Ring expander
- Ring groove cleaner

- Safety glasses

Safety gloves
Screwdriver
Seal installation tools
Seal removal tools
Service manuals (as appropriate)
Shop towels
Soft headed hammer
Square or scale
Square piece of square stock, $^3/_4$"
Starter rope
Surface plate

Tachometer
Telescoping gauge
Test light
Test plug
Thread repair kit
Torque wrench
Tubing wrenches

Valve face grinding equipment
Valve guide reamers
Valve guide removal tools
Valve seat driver
Valve seat grinding equipment
Valve seat removal tools
Valve spring compressor
Valve spring tension tester
V-blocks (2)
Vernier caliper
Voltmeter

Water hose
Wire brush
Wire, various lengths
Wooden scraper
Wrench set

SMALL ENGINE REPAIR

Two-Stroke and Four-Stroke Cycle

REFERENCES

(NOTE: The following is an alphabetical list of references used in completing this text.)

A Look at Service Safety. Tecumseh, Michigan: Tecumseh Products Co.

American Association for Vocational Instructional Materials. *Small Engines Volume 1 and 2.* Athens, Georgia: AAVIM, 1974.

An Accident Prevention Program for School Shops and Laboratories. Washington, D.C.: Office of Education/U.S. Department of Health, Education, and Welfare.

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Bohn, Ralph C., and MacDonald, Angus J. *Power: Mechanics of Energy Control.* Bloomington, Illinois: McKnight and McKnight, 1970.

Chilton's Motorcycle Repair Manual. Radnor, Pennsylvania: Chilton's Motor Co., 1975.

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Chilton's Motorcycle Troubleshooting Guide. Radnor, Pennsylvania: Chilton Book Company, 1973.

Comprehensive Small Engine Repair. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

Crouse, William H. and Donald L. Anglin. *Small Engine Mechanics.* Second Edition. New York: Gregg Division, McGraw-Hill Book Company, 1980.

Federal Register. Vol. 36, Number 105. Part II. Department of Education.

Foutes, William. *Diesel Mechanics: Fundamentals.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1982.

Fuels and Lubricants. Fifth Edition. Athens, Georgia: American Association for Vocational Instructional Materials, 1983.

Fundamentals of Service: Fasteners. Moline, Illinois: Deere and Company, 1979.

Fundamentals of Service: Fuels, Lubricants, and Coolants. Moline, Illinois: Deere and Company, 1979.

Fuqua, Lou and Debbie. *Parts Specialist.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1982.

Harley-Davidson Service Manual: Sportster XL/XLH/XLCH, 1970 to 1973. Harley-Davidson Motor Co., Inc., 1972.

Hendrix, Laborn. *Cement Masonry.* Stillwater, Oklahoma: Curriculum and Instructional Materials Center/State Department of Vocational and Technical Education and Associated General Contractors, 1974.

Herd, Amon. *Small Engine Repair Series* (for Briggs and Stratton Engines). Columbia, Missouri: Instructional Materials Laboratory, University of Missouri-Columbia.

(NOTE: The following manuals from the above series were utilized in the development of this material.)

1. Carburetors: Service and Repair
2. Governors: Repair and Adjustment
3. Lubricating Small Engines
4. Maintenance Procedures: Height Adjustment, Blade Balancing and Sharpening, and Mufflers
5. Starters: Service and Repair
6. Troubleshooting Small Engines
7. Valves: Service and Repair

Hydraulics. Moline, Illinois: Deere and Company, 1979.

Parady, Harold W., and J. Howard Turner. *Electrical Energy.* Athens, Georgia: American Association for Vocational Instructional Materials, 1976.

Roth, Alfred C. and Ronald J. Baird. *Small Gas Engines.* South Holland, Illinois: The Goodheart-Wilcox Company, Inc., 1975.

Safety Practices and Procedures in School Shops. Division of Vocational Education/New Jersey Department of Education.

Safety Standards. Consumer Product Safety Commission.

Small Engines. Volume 1. Athens, Georgia: American Association for Vocational Instructional Materials.

Small Engines, Volume 2. Athens, Georgia: American Association for Vocational Instructional Materials, 1971.

Small Engine Service Manual. Eleventh Edition. Kansas City, Missouri: Technical Publications Division, Intertec Publishing Corporation, 1976.

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Small Gasoline Engines. University Park, Pennsylvania: College of Agriculture, The Pennsylvania State University, 1969.

Stockel, Martin W. *Auto Mechanics Fundamentals.* South Holland, Illinois: Goodheart-Wilcox Co., 1982.

The ABC's of Fire Protection. Belleville, New Jersey: Kidde Portable Extinguishers/Walter Kidde and Co., Inc.

Twin Cylinder Repair Instructions. Milwaukee, Wisconsin: Briggs and Stratton Corporation, 1980.

SUGGESTED SUPPLEMENTAL MATERIALS

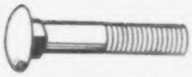
Publications

1. *Essentials of Fire Fighting.* Second Edition. Stillwater, Oklahoma: Fire Protection Publications, Oklahoma State University, 1983.
2. *Fire Service First Aid Practices.* Fifth Edition. Stillwater, Oklahoma: Fire Protection Publications, Oklahoma State University, 1977.
3. *Fire Fighter's Guide to Electrical Safety.* Columbia, Missouri: University of Missouri Fire Training Center.
4. Kigin, Dennis J. *Teacher Liability in School Shop Accidents.* Ann Arbor, Michigan: Prakken Publications, Inc., 1983.

Audiovisual aids

1. Film — "Housekeeping Means Safekeeping." Journal Films, Inc., 930 Pinter Avenue, Evanston, Illinois 60202.
2. Film — "Stop a Fire Before it Starts." Journal Films, 930 Pinter Avenue, Evanston, Illinois 60202.
3. Film — "The Last Round." Journal Films, 930 Pinter Avenue, Evanston, Illinois 60202.
4. Film — "We'll See Tomorrow." Journal Films, 930 Pinter Avenue, Evanston, Illinois 60202.
5. Film — "It's Up to You." Harvest Films, Inc., 309 Fifth Avenue, New York, New York 10016.
6. Film — "You Pack Your Own Chute." Ramic Productions, 4910 Birch, Newport Beach, California 92660.

TEST



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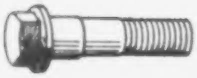

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5. Complete the following list of statements concerning how bolt sizes, lengths, and threads are measured by correctly filling in the blank.

   a. Size of bolt is determined by measuring the diameter of the thread end

   b. Length of bolt is determined by measuring the distance from bottom of the head to the end of the threads

   c. ____

   ____

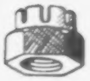
6. Select true statements concerning SAE grade and metric bolts by placing an "X" in the appropriate blanks.

   _____a. SAE grade and metric bolts are identified by markings on the heads of the bolt

   _____b. Metric bolts use slashes for identification

   _____c. SAE grade bolts use numbers for identification which correspond to bolt strength; increasing numbers represent increasing strength

7. Identify typical nuts.



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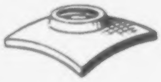

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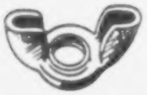

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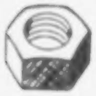

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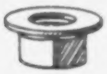

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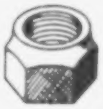

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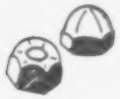

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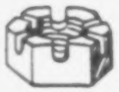

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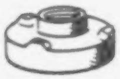

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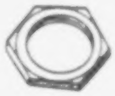

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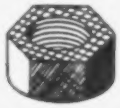

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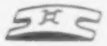

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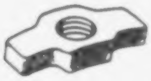

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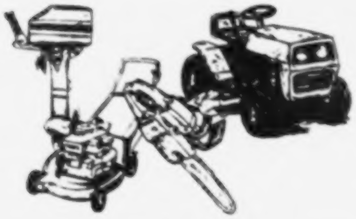


Safety
Unit I-A

UNIT OBJECTIVE

After completion of this unit, the student should be able to distinguish between safe and unsafe shop practices, select the fire extinguishers for the classes of fires, and match the colors of the safety color code with their applications. Competencies will be demonstrated by correctly performing the procedures outlined in the assignment sheets and by scoring 100 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to safety with their correct definitions.
2. Match the colors of the safety color code with their correct applications.
3. Complete a list of steps for maintaining a safe and orderly shop.
4. Match the classes of fires with their correct descriptions.
5. Identify the three components of the fire triangle.
6. Match types of fire extinguishers with their classes of fires.
7. Distinguish between safe and unsafe shop practices.
8. Complete a list of statements concerning Consumer Product Safety Commission standards.
9. List the four general shop safety rules.

OBJECTIVE SHEET

10. Complete a student safety pledge form (Assignment Sheet #1).

11. Complete a student shop safety inspection checklist (Assignment Sheet #2).

SAFETY
UNIT I-A

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with assignment sheets.

H. Integrate the following activities throughout the teaching of this unit:

1. Invite a small engine shop owner to talk with students about career opportunities and discuss the occupational outlook for small engine mechanics.
2. Have students make safety posters for use in shop area.

   (NOTE: Have a poster contest to stimulate interest.)
3. Discuss procedures outlined in the assignment sheets.
4. Have fire chief demonstrate the proper use of fire extinguishers.
5. Show students how to check fire extinguishers.
6. Show safety films.

   (NOTE: See suggested supplemental materials list for film titles.)
7. Discuss the fire evacuation plan for the classroom and shop and procedures for tornado alerts.

SUGGESTED ACTIVITIES

8. Have a local Red Cross instructor demonstrate emergency first aid procedures, especially those related to treating cuts, electrical shock, and burns, and the use of cardio-pulmonary resuscitation (CPR).

9. Demonstrate the procedure for lifting a heavy object.

10. Discuss the Consumer Product Safety Commission standards and explain the liability of working with equipment.

11. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

  1. TM 1 — The Fire Triangle
  2. TM 2 — Types of Fire Extinguishers
  3. TM 3 — Use Care with Gasoline
  4. TM 4 — Proper Use of Equipment
  5. TM 5 — Unplug Equipment Before Working
  6. TM 6 — Proper Handling of Batteries

E. Assignment sheets

  1. Assignment Sheet #1 — Complete A Student Safety Pledge Form
  2. Assignment Sheet #2 — Complete A Student Shop Safety Inspection Checklist

F. Test

G. Answers to test

SUGGESTED ACTIVITIES

REFERENCES USED IN DEVELOPING THIS UNIT

A. *The ABC's of Fire Protection.* Belleville, New Jersey: Kidde Portable Extinguishers/Walter Kidde and Co., Inc.

B. *An Accident Prevention Program for School Shops and Laboratories.* Washington, D.C.: Office of Education/U.S. Department of Health, Education, and Welfare.

C. *Federal Register. Vol. 36, Number 105. Part II.* Department of Education.

D. *Safety Practices and Procedures in School Shops.* Division of Vocational Education/ New Jersey Department of Education.

E. *A Look at Service Safety.* Tecumseh, Michigan: Tecumseh Products Co.

F. *Safety Standards.* Consumer Product Safety Commission.

SUGGESTED SUPPLEMENTAL MATERIALS

A. Publications

1. *Essentials of Fire Fighting.* Second Edition. Stillwater, Oklahoma: Fire Protection Publications, Oklahoma State University, 1983.

2. *Fire Service First Aid Practices.* Fifth Edition. Stillwater, Oklahoma: Fire Protection Publications, Oklahoma State University, 1977.

3. *Fire Fighter's Guide to Electrical Safety.* Columbia, Missouri: University of Missouri Fire Training Center.

(NOTE: The above publications are available through Fire Protection Publications, Oklahoma State University, Stillwater, Oklahoma 74076, or call (405) 624-5723, or toll-free 1-800-654-4055 [except in Oklahoma, Hawaii, or Alaska].)

4. Kigin, Dennis J. *Teacher Liability in School Shop Accidents.* Ann Arbor, Michigan: Prakken Publications, Inc., 1983.

B. Audiovisual aids

1. Film — "Housekeeping Means Safekeeping." Journal Films Inc., 930 Pinter Avenue, Evanston, Illinois 60202.

2. Film — "Stop a Fire Before it Starts." Journal Films, 930 Pinter Avenue, Evanston, Illinois 60202.

3. Film — "The Last Round." Journal Films, 930 Pinter Avenue, Evanston, Illinois 60202.

SUGGESTED ACTIVITIES

4. Film — "We'll See Tomorrow." Journal Films, 930 Pinter Avenue, Evanston, Illinois 60202.
5. Film — "It's Up to You." Harvest Films, Inc., 309 Fifth Avenue, New York, New York 10016.
6. Film — "You Pack Your Own Chute." Ramic Productions, 4910 Birch, Newport Beach, California 92660.

(NOTE: Oklahoma teachers may order copies of the above films through the Resource Library, State Dept. of Vocational-Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

SAFETY
UNIT I-A

INFORMATION SHEET

I. **Terms and definitions**

A. Safety — State or condition of being safe; freedom from danger, risk, or injury

B. Accident — Any suddenly occurring, unintentional event which causes injury or property damage

C. First aid — Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

D. Carbon monoxide — Colorless, odorless, very poisonous gas formed by incomplete combustion

E. Battery — Number of complete electrical cells assembled in one housing or case; used in small engines to run and/or start the engine

F. Service manual — Professional book giving exact details, tools, and procedures for servicing one or more types of engines

G. Compressed oxygen — Oxygen processed for purity and compressed in bottles

Example: Oxygen bottle for oxyacetylene welding

H. Carburetor and/or parts cleaner — Chemical solution for dissolving deposits such as grease, varnish, gum, and paint from parts without damage to the metal

I. OSHA — Occupational Safety and Health Act

J. CPSC — Consumer Product Safety Commission

II. **Colors and applications of the safety color code**

A. Green — Designates location of safety and first aid equipment

(NOTE: This is applied to noncritical parts of equipment and machined surfaces, nameplates, and bearing surfaces.)

B. Yellow — Designates caution

(NOTE: This is applied to operating levers, wheels, handles, and hazardous areas which may cause stumbling, falling or tripping.)

INFORMATION SHEET

C. Orange — Designates dangerous parts of equipment which may cut, crush, shock, or otherwise injure

(NOTE: This is applied to electrical switches, interior surfaces of doors, on fuse and electrical power boxes, movable guards, and parts.)

D. Red — Identifies the location of fire fighting equipment

(NOTE: Emergency fire exits shall be designated in red. Gasoline cans should be painted red with additional identification in the form of a yellow band around the can. Buttons or levers for electrical switches, used for stopping of machinery, should also be designated in red.)

E. Blue — Designates caution against starting equipment while it is being worked on, or against the use of defective equipment

(NOTE: Blue tag should be lettered "Out of Order.")

F. Ivory — Reflects light and "shows the way"

(NOTE: This is applied to label edges, vise jaws, and edges of tool rests.)

III. **Steps for maintaining a safe and orderly shop**

A. Arrange machinery and equipment to permit safe, efficient work practices and ease in cleaning

B. Stack or store materials and supplies safely in proper places

C. Store tools and accessories safely in cabinets, racks, or other suitable devices

D. Keep working areas and work benches clear and free of debris and other hazards

E. Keep floors clean and free from obstructions and slippery substances

F. Keep aisles, traffic areas, and exits free of material and other debris

G. Properly dispose of combustible materials or store them in approved containers

H. Store oily rags in self-closing or spring-lid metal containers

I. Know the proper procedures to follow in keeping the work area clean and orderly

J. Have sufficient brooms, brushes, or other housekeeping equipment readily available

INFORMATION SHEET

IV. **Class of fires**

A. Class A — Fires that occur in ordinary combustible materials

Example: Wood, rags, and rubbish

B. Class B — Fires that occur with flammable liquids

Example: Gasoline, oil, grease, paints, and thinners

C. Class C — Fires that occur in or near electrical equipment

Example: Motors, switch panels and electrical wiring

D. Class D — Fires that occur with combustible metals

Example: Magnesium

V. **Components of the fire triangle (Transparency 1)**

A. Fuel — Any combustible material

B. Heat — Enough to raise the fuel to its ignition temperature

C. Oxygen — Necessary to sustain combustion

(NOTE: To produce fire these three elements are necessary and must be present at the same time. If any one of these three is missing, a fire cannot be started. With the removal of any one of them, the fire will be extinguished.)

VI. **Types of fire extinguishers and classes of fires (Transparency 2)**

A. Pressurized water — Used on Class A fires

(CAUTION: Never use this type of extinguisher on electrical fires.)

B. Carbon dioxide (CO_2) — Used on Class B and C fires

C. Dry chemical — Used on Class B, C, and D fires

(NOTE: On Class D fires, dry sand is as effective as any dry chemical other than Purple X. The cost of the Purple X chemical places it out of reach of most shops.)

D. Foam — Used on Class A and B fires

(NOTE: This type operates by turning extinguisher upside down.)

INFORMATION SHEET

VII. **Rules of safety**

A. Fire prevention (Transparency 3)

1. Never strike sparks in a room or area where flammable liquids are used or stored

2. Use only approved safety cans for storage of flammable liquids and label them properly

3. Do not fill a hot or running engine with gasoline

   (NOTE: It may spill and cause a fire.)

4. Use a commercial nonflammable cleaner for cleaning tools and parts

   (NOTE: Do not use gasoline as a cleaner for tools or parts.)

5. Change any oil or gasoline soaked clothes immediately

   (NOTE: A spark, a hot exhaust manifold, or an open flame can easily ignite such clothing.)

6. Learn the location and use of fire extinguishers for each class of fire

7. Dispose of oil or gasoline soaked rags and other debris in self-closing, air-tight metal containers provided for this purpose

8. Avoid placing live electrical wires near fuel lines, carburetors, gas tanks, or fuel storage containers

B. Oil and grease

1. Wipe up at once any spilled oil, grease, or other liquids

   (NOTE: Use oil absorbent materials on the oil; this will prevent slipping.)

2. Do not direct oil spray toward other workers

3. Always have the proper container at hand to catch fuel, oil, or other fluids before attempting to drain them

   (NOTE: When the fluid has been drained, move it to a safe place away from fire hazards.)

INFORMATION SHEET

4. Do not pour old oil on the ground, down a drain, or into a natural watershed

   (NOTE: Consult your instructor regarding local ordinances for disposal of oil and grease.)

5. Do not oil an engine while it is running or attempt to oil or wipe moving parts

C. Eye protection — Always wear safety goggles while performing the following operations or as required by state and school laws or policy

   1. Grinding, chipping, or drilling
   2. Working under equipment
   3. Operating abrasive discs
   4. Charging batteries or using caustic cleaning compounds

      (NOTE: Wear splash proof goggles when using acids or caustic liquids such as carburetor and parts cleaners.)

D. Electrical

   1. *Any* and *all* dangerous conditions of equipment should be reported to the instructor
   2. Treat all electrical equipment as "live" until you have carefully checked
   3. Use third wire cords and plugs to ground all portable lights and tools

      (NOTE: This is not necessary on tools that are double insulated.)

   4. Check the condition of cords, plugs, and sockets
   5. Eliminate cords and wires as trip hazards
   6. Coil and hang or store power tools and cords properly
   7. Be prepared to turn off any electrical power switch and/or main switch in case of emergency

E. Air pressure

   1. Never use compressed air equipment for dusting off clothing or work benches

      (NOTE: Flying particles may be blown into the eyes or skin of yourself or others.)

INFORMATION SHEET

2. *Never* use compressed oxygen in place of compressed air

3. Use compressed air only for the purpose for which it is intended and in a manner approved by OSHA

F. Equipment (Transparencies 4 and 5)

1. Do not operate any machine without having been instructed in its use

2. Never start an engine before determining that everyone is in the clear

3. Never start an engine without knowing how to shut it off and being ready to do so if the need calls for it

4. Keep hands and clothing away from moving parts

   (NOTE: A few of the moving parts that concern us are flywheels, blades, fans, gears, pulleys, belts, chains, generators, and power take off (PTO) shafts.)

5. Never run an engine in an inadequately ventilated place

   (NOTE: Remember that carbon monoxide fumes from an engine can kill.)

6. Read and heed all notes and cautions

   (NOTE: Throughout this material and in almost every service manual you will come across many passages with these headings.)

7. Read instructions thoroughly and follow them carefully

   (NOTE: Do not attempt shortcuts.)

8. If you lack the proper tools or have doubts of your ability to do the job correctly, consult your instructor

9. Light your work area adequately

   (NOTE: Have a portable safety light for working under equipment.)

10. Wear reasonably tight fitting, appropriate clothing while working in the shop

11. Never wear a necktie, necklace, or other loose apparel to work in the shop

    (NOTE: Button sleeves and secure or cover long hair behind your head or up to prevent snagging in power equipment.)

INFORMATION SHEET

12. Always disconnect and ground the wire from the spark plug before inspecting or repairing any mower, tiller, saw, or other power equipment

    (NOTE: The engine may accidently start and cause serious injury.)

13. After reassembly be sure all parts, nuts, bolts, and screws are securely in place

    (NOTE: Loose or missing parts can interfere with the operation of the equipment and damage or injury may result.)

14. Use ear protection as needed

G. Batteries (Transparency 6)

1. Handle batteries with care and use a battery strap or carrier

2. Always hold battery upright and set securely so there is no danger of spilling acid

3. Never smoke, use an open flame, or cause a spark on battery terminals especially on a charging battery or charging area

   (NOTE: Hydrogen gas is given off in charging and it may explode and spatter acid.)

4. Wear protective clothing such as chemical goggles, rubber aprons, gloves, and boots while working in battery charging operations

5. When mixing battery solutions, always pour acid into water

   (NOTE: Reversing this mixing procedure to water into acid increases the possibility of splashing the acid on you.)

6. If acid splashes on you, flush immediately with plenty of cold water and notify instructor

   (NOTE: This is especially important if acid gets in your eyes.)

7. Do not short circuit the battery to test it

   (NOTE: A fire or explosion may result.)

8. Prevent accidental short circuits by disconnecting and insulating grounded battery cable before working on equipment

9. Use appropriate charging amperage when charging battery and remove all battery caps

10. Never charge a frozen battery

INFORMATION SHEET

VIII. **Consumer Product Safety Commission (CPSC) standards**

(NOTE: June 30, 1982, marked the last day a walk-behind power lawnmower could be built or imported for U.S. consumers without complying with the CPSC "Safety Standard for Walk-Behind Power Lawn Mowers.")

A. The standard defines a "walk-behind lawnmower" as a grass cutting machine with a minimum cutting width of 12 inches

(NOTE: Commercial lawnmowers not customarily produced and sold to consumers are not subject to the standard.)

B. The standard specifies performance requirements for most rotary lawnmowers manufactured or imported after June 30, 1982 and, in addition to the warning label, requires the following:

(NOTE: Prior to June 30, 1982, the first phase of the standard only required a warning label stating "Danger," "Keep hands and feet away.")

1. Every affected rotary lawnmower must carry a certification label
2. The path of the blade on a rotary lawnmower be shielded in such a manner that the unit can successfully pass specified tests, including a "foot probe" test and an "obstruction" test
3. A blade control system is required that:
    a. Prevents the blade from operating unless the operator actuates the control,
    b. Requires continuous contact with the control to keep the blade in motion, and
    c. Stops the blade completely within three seconds after release of the control

    (NOTE: For electrically powered lawnmowers or electric start lawnmowers, the starting controls must be located within approximately 15" of the rear-most part of the lawnmower handle.)
4. All units must be equipped with a second control, either a separate safety lever or a device incorporated into the blade control, so that two distinct actions are required to restart the blade

INFORMATION SHEET

C. The standard expressly applies to the manufacturer and initial sale to consumers; it is silent with respect to service and repair of so-called "compliance" units

(NOTE: Any modification made by a dealer at the time of the sale to a consumer that renders the mower noncomplying would be a violation of the standard. However, if later the owner brings the lawnmower in for servicing and asks a dealer or repair person to disable a safety feature required by the standard, such an action would not be in violation of the standard since it does not involve a sale. Dealers are encouraged not to eliminate any safety feature since such action may create potential liability in the event someone is subsequently injured because a safety feature was missing.)

IX. **General shop safety rules**

A. All injuries should be treated at once

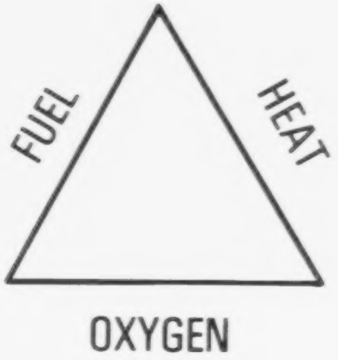
B. Safety equipment and shoes should be used and worn as required

C. Running and horseplay are not permitted in the shop at any time

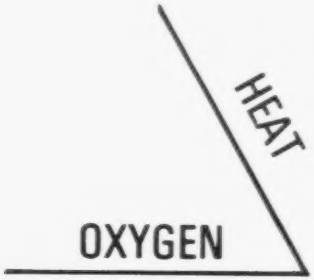
D. *Any* and *all* dangerous conditions or damaged equipment should be reported to the instructor

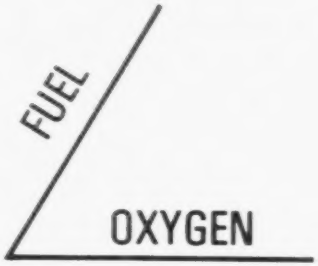
The Fire Triangle

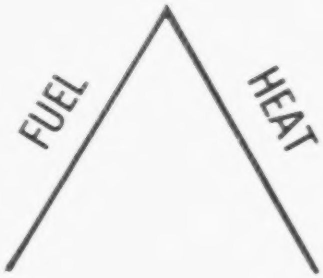
To produce fire, three things must be present at the same time.


FUEL
HEAT
OXYGEN

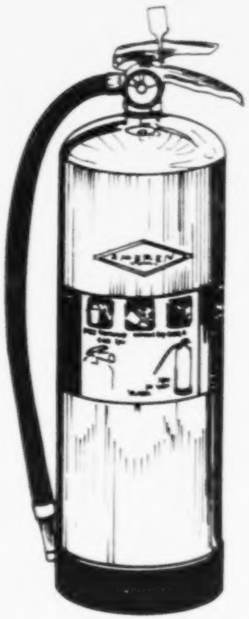
If any one of the three is missing, a fire cannot be started or, with the removal of any one, the fire will be extinguished.


HEAT
OXYGEN

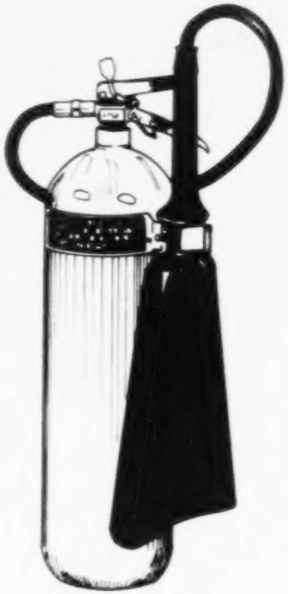

FUEL
OXYGEN



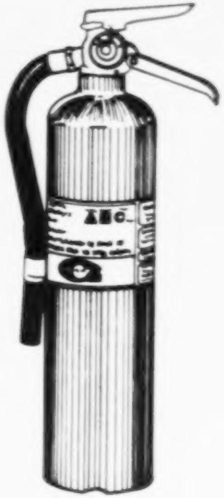
Types of Fire Extinguishers



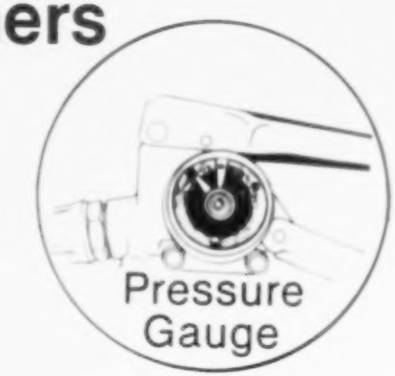
Pressurized Water

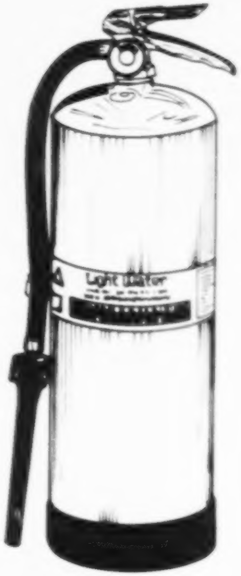


Carbon Dioxide CO_2



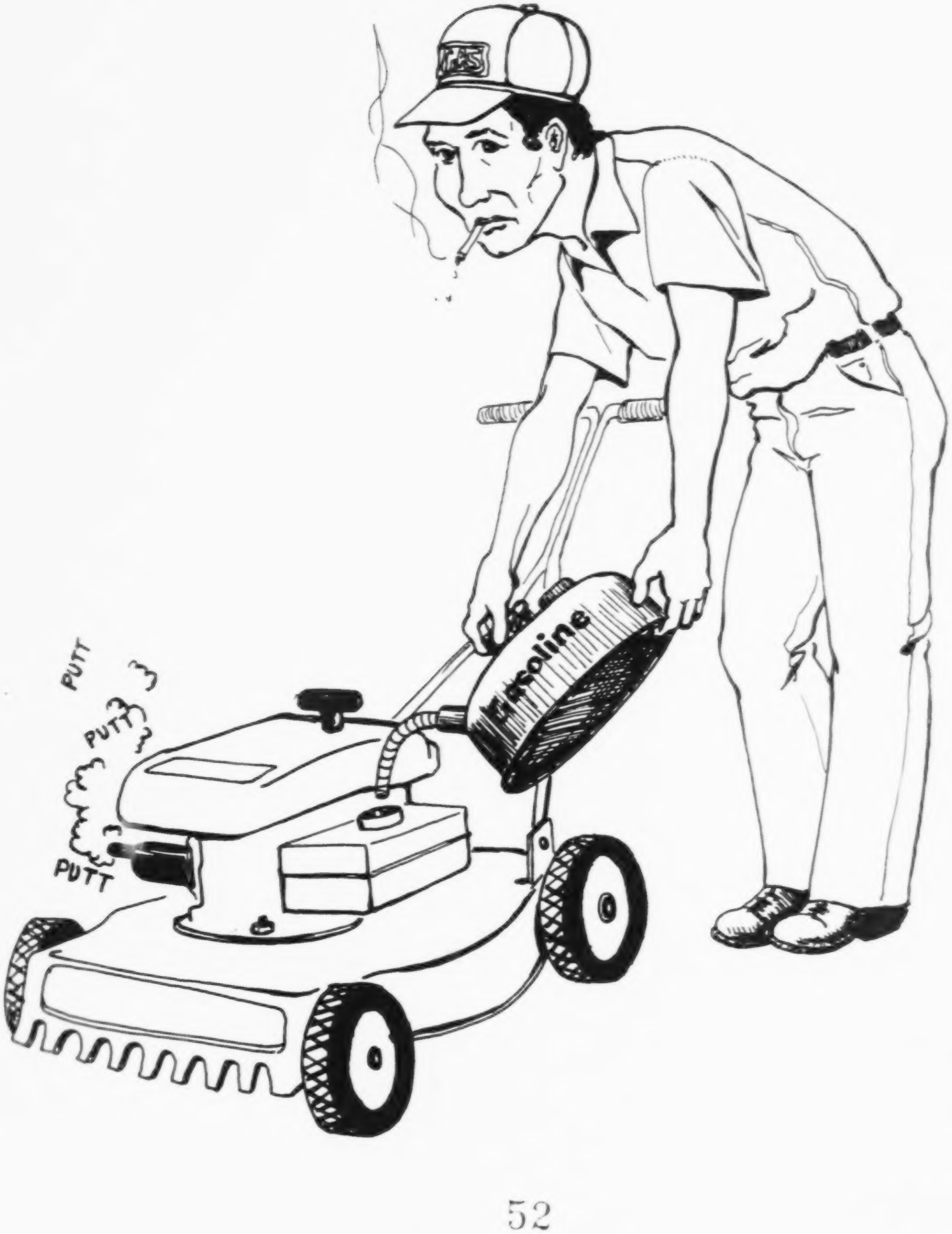
Dry Chemical


Pressure Gauge

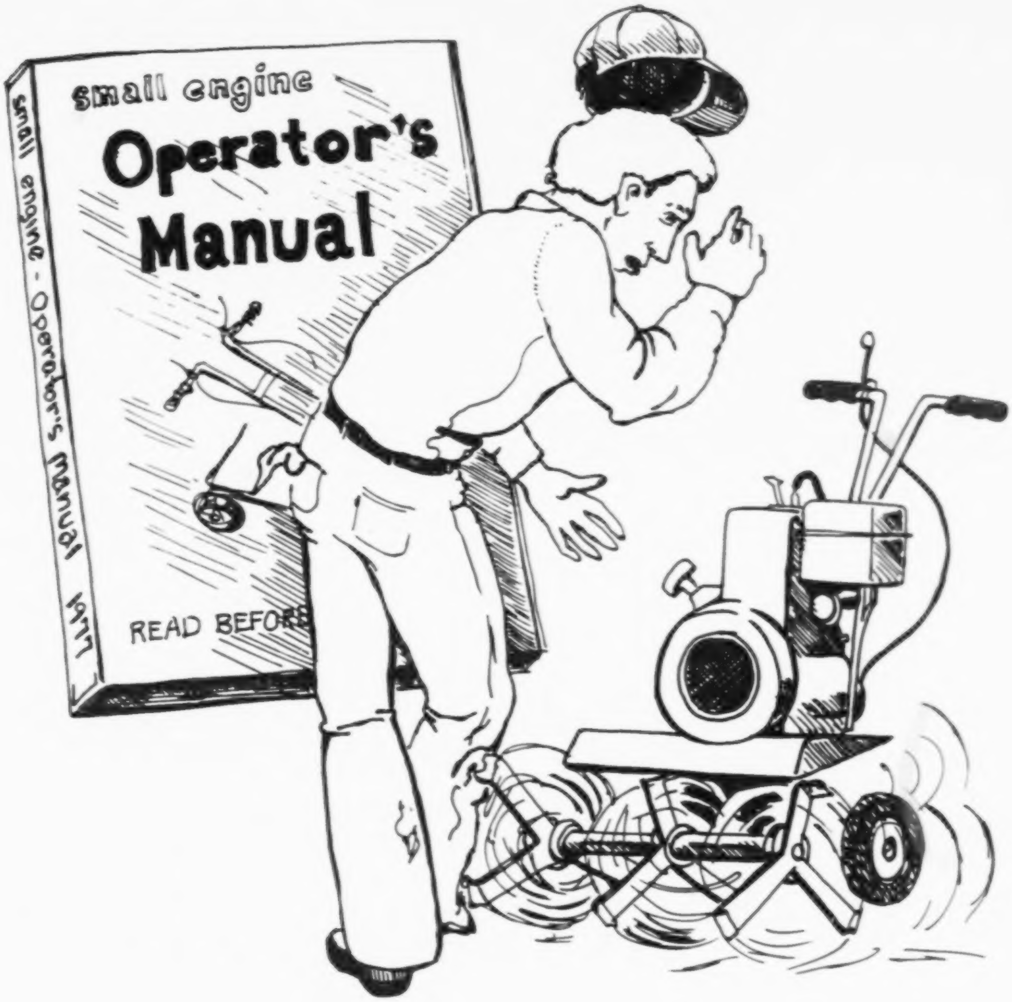


Foam

Use Care With Gasoline


PUTT
PUTT
PUTT
Gasoline

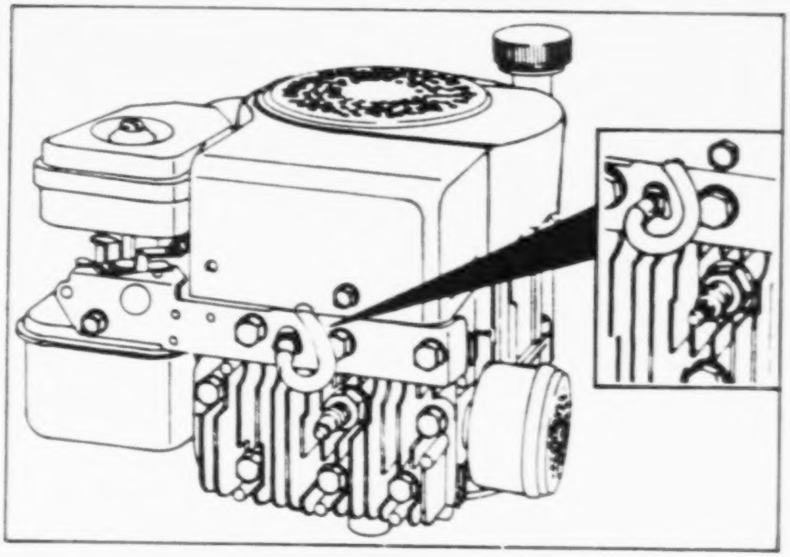
Proper Use of Equipment


small engine
Operator's Manual
small engine - Operator's manual
READ BEFORE

Read Your Operator's Manual Before Operating Equipment

Do Not Wear Loose Fitting Clothing Around Equipment, and Stay Clear of the Moving Parts While the Engine Is Running

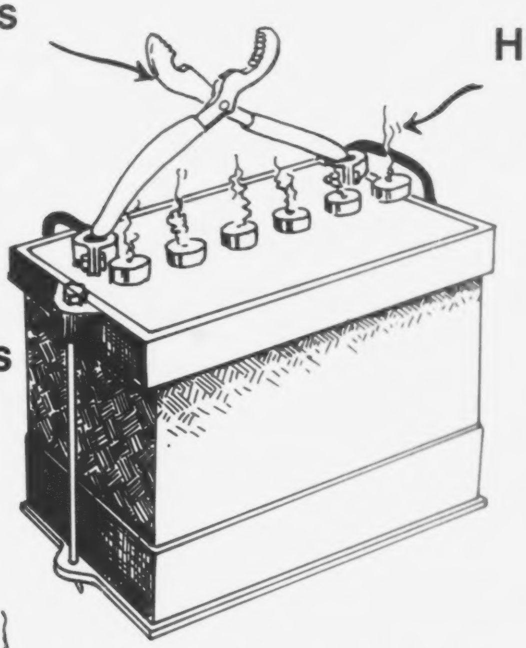
Unplug Equipment Before Working

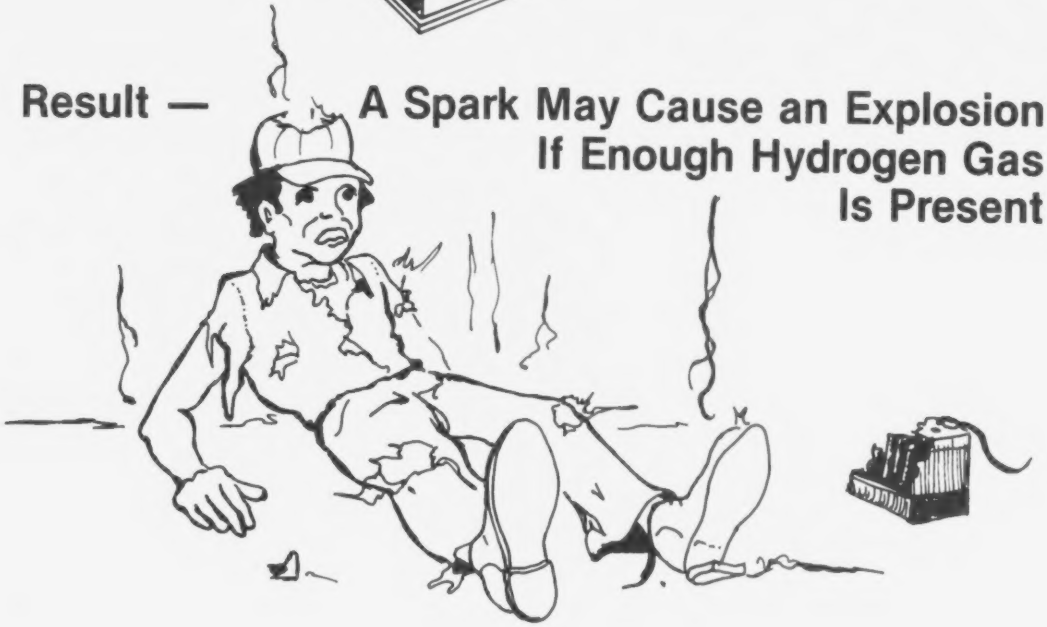


Disconnect the Spark Plug Lead
to Keep the Engine From
Accidentally Starting

Proper Handling of Batteries

Do Not Arc Terminals to Test — Or to Cause a Spark


Pliers
Hydrogen Gas
Carelessness



Result — A Spark May Cause an Explosion If Enough Hydrogen Gas Is Present

SAFETY
UNIT I-A

ASSIGNMENT SHEET #1 — COMPLETE A STUDENT SAFETY PLEDGE FORM

Read and complete the following student safety pledge form by correctly filling in the blanks.

STUDENT SAFETY PLEDGE FORM

__________ __________ __________, who is enrolled in Vocational __________ __________, will as a part of the shop experience, operate machines, providing that the parent or guardian gives written permission.

It is understood that each student will be given proper instruction, both in the use of the equipment and correct safety procedures concerning it, before being allowed to operate the machines. The student must assume responsibility for following safe practices; therefore, we ask that the student subscribe to the following safety pledge.

1. I PROMISE TO FOLLOW ALL SAFETY RULES FOR THE SHOP.
2. I PROMISE NEVER TO USE A MACHINE WITHOUT FIRST HAVING PERMISSION FROM THE INSTRUCTOR.
3. I WILL NOT ASK PERMISSION TO USE A PARTICULAR MACHINE UNLESS I HAVE BEEN INSTRUCTED IN ITS USE, AND HAVE MADE 100% ON THE SAFETY TEST FOR THAT MACHINE.
4. I WILL REPORT ANY ACCIDENT OR INJURY TO THE TEACHER IMMEDIATELY.

DATE ________ STUDENT'S SIGNATURE ________________________________

I hereby give my consent to allow my son or daughter to operate all machines and equipment necessary in carrying out the requirements of the course in which he/she is enrolled.

DATE ________ PARENT'S SIGNATURE ________________________________
(If required)

Parents are cordially invited to visit the shop to inspect the machines and to see them in operation.

SAFETY
UNIT I-A

ASSIGNMENT SHEET #2 — COMPLETE A STUDENT SHOP SAFETY INSPECTION CHECKLIST

Complete the following safety inspection checklist by physically conducting an inspection of the shop area.

CHECKING PROCEDURE

Draw a circle around the appropriate letter, using the following letter scheme:

S — Satisfactory (needs no attention)
A — Acceptable (needs some attention)
U — Unsatisfactory (needs immediate attention)

Recommendations should be made in all cases where a "U" is circled. Space is provided at the end of the form for such comments.

A. GENERAL PHYSICAL CONDITION

1.	Machines, benches, and other equipment are arranged to conform to good safety practices	S	A	U
2.	Condition of stairways and ramps	S	A	U
3.	Condition of aisles	S	A	U
4.	Condition of floors	S	A	U
5.	Condition of walls, windows, and ceiling	S	A	U
6.	Illumination is safe, sufficient, and well placed	S	A	U
7.	Ventilation is adequate and proper for conditions	S	A	U
8.	Temperature control	S	A	U
9.	Fire extinguishers are of proper type, adequately supplied, properly located, and maintained	S	A	U
10.	Teacher and students know location of and how to use proper type for various fires	S	A	U
11.	Number and location of exits is adequate and properly identified	S	A	U

ASSIGNMENT SHEET #2

12. Walls are clear of objects that might fall S A U
13. Utility lines are properly identified S A U
14. Air in shop is free from excessive dust and smoke S A U
15. Evaluation for the total rating of GENERAL PHYSICAL CONDITION S A U

B. HOUSEKEEPING

1. General appearance of orderliness S A U
2. Adequate and proper storage space for tools and materials S A U
3. Benches are kept orderly S A U
4. Corners are clean and clear S A U
5. Special tool racks, in orderly condition, and provided at benches and machines S A U
6. Tool, supply, and/or material room is orderly S A U
7. Sufficient scrap boxes are provided S A U
8. Scrap stock is put in scrap boxes promptly S A U
9. Materials are stored in an orderly and safe condition S A U
10. A spring lid metal container is provided for waste and oily rags S A U
11. Dangerous materials are stored in metal cabinets S A U
12. Machines have been color conditioned S A U
13. Safety cans are provided for flammable liquids S A U
14. Floors are free of oil, water, and foreign material S A U
15. Evaluation for the total rating for HOUSEKEEPING S A U

ASSIGNMENT SHEET #2

C. EQUIPMENT

1. Machines are arranged so that workers are protected from hazards of other machines and passing students S A U
2. Danger zones are properly indicated and guarded S A U
3. All gears and moving belts are protected by permanent enclosure guards S A U
4. All equipment control switches are easily available to operator S A U
5. Nonskid areas are provided around machines S A U
6. Tools are kept sharp, clean, and in safe working order S A U
7. Evaluation for the total rating for EQUIPMENT S A U

D. ELECTRICAL INSTALLATION

1. All switches are enclosed S A U
2. There is a master control switch for all electrical installations S A U
3. All electrical extension cords are in safe condition and are not carrying excessive loads S A U
4. All machine switches are within easy reach of the operators S A U
5. Individual cut-off switches are provided for each machine S A U
6. No temporary wiring S A U
7. Evaluation for the total rating for ELECTRICAL INSTALLATION S A U

ASSIGNMENT SHEET #2

E. **PERSONAL PROTECTION** (Read only)

1. Goggles or protective shields are provided and required for all work where eye hazards exist
2. If individual goggles are not provided, hoods and goggles are properly disinfected before use
3. Shields and goggles are provided for welding
4. Rings and other jewelry are removed by students when working in the shop
5. Proper kind of wearing apparel is worn for the job being done
6. Leggings and safety shoes are worn in special classes
7. Respirators are provided for dusty or toxic atmospheric conditions such as when spraying occurs in the finishing room
8. Provisions are made for cleaning and sterilizing respirators
9. Students are examined for safety knowledge
10. Sleeves are rolled above elbows when operating machines
11. Clothing of students is free from loose sleeves, floppy ties, and loose coats

RECOMMENDATIONS

SAFETY
UNIT I-A

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

______a. State or condition of being safe; freedom from danger, risk, or injury

______b. Any suddenly occurring, unintentional event which causes injury or property damage

______c. Occupational Safety and Health Act

______d. Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

______e. Chemical solution for dissolving deposits such as grease, varnish, gum and paint from parts without damage to the metal

______f. Professional book giving exact details, tools, and procedures for servicing one or more types of engines

______g. Oxygen processed for purity and compressed in bottles

______h. Number of complete electrical cells assembled in one housing or case; used in small engines to run and/or start the engine

______i. Colorless, odorless, very poisonous gas formed by incomplete combustion

______j. Consumer Product Safety Commission

1. OSHA
2. Battery
3. CPSC
4. Accident
5. First aid
6. Carbon monoxide
7. Service manual
8. Compressed oxygen
9. Carburetor and/or parts cleaner
10. Safety

TEST

2. Match the colors of the safety color code on the right with their correct applications.

______a. Designates caution

______b. Identifies the location of fire fighting equipment

______c. Designates location of safety and first aid equipment

______d. Designates dangerous parts of equipment which may cut, crush, shock, or otherwise injure

______e. Designates caution against starting equipment while it is being worked on, or against the use of defective equipment

______f. Reflects light and "shows the way"

1. Green
2. Ivory
3. Orange
4. Yellow
5. Blue
6. Red

3. Complete the following list of steps for maintaining a safe and orderly shop by correctly filling in the blanks.

a. Arrange machinery and equipment to permit safe, efficient work practices and ____________________

b. ________________ or store materials and supplies safely in proper places

c. Store tools and accessories safely in ________________, racks, or other suitable devices

d. Keep working areas and work benches clear and free of debris and other ________________

e. Keep floors clean and free from obstructions and ________________ substances

f. Keep aisles, traffic areas, and ________________ free of material and other debris

g. Properly dispose of ________________ materials or store them in approved containers

h. Store oily rags in self-closing or spring-lid ________________ containers

i. Know the proper procedures to follow in keeping the work area clean and ________________

j. Have sufficient brooms, brushes, or other ________________ equipment readily available

TEST

4. Match the classes of fire on the right with their correct descriptions.

_____a. Fires that occur with flammable liquids

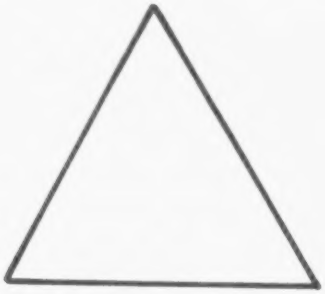
_____b. Fires that occur in ordinary combustible materials

_____c. Fires that occur in or near electrical equipment

_____d. Fires that occur with combustible metals

1. Class A
2. Class B
3. Class C
4. Class D

5. Identify the three components of the fire triangle.



6. Match types of fire extinguishers on the right with their classes of fires.

_____a. Class B

_____b. Class C

_____c. Class A

_____d. Class D

1. Pressurized water
2. Carbon dioxide (CO_2)
3. Dry chemical
4. Foam

TEST

7. Distinguish between safe and unsafe shop practices by placing an "S" in the appropriate blanks if the practice is safe and a "U" if it is unsafe.

   a. Fire prevention

   _____1) Never strike sparks in a room or area where flammable liquids are used or stored

   _____2) Use only approved safety cans for storage of flammable liquids and label them properly

   _____3) Gasoline may be poured into an engine at any time

   _____4) Wash engine parts in a pan of gasoline

   _____5) Change any oil or gasoline soaked clothes immediately

   _____6) Learn the location and use of fire extinguishers for each class of fire

   _____7) Dispose of oily rags by throwing them in a corner or under a table out of the way

   _____8) Avoid placing live electrical wires near fuel lines, carburetors, gas tanks, or fuel storage containers

   b. Oil and grease

   _____1) When a job is messy and more oil will be spilled on the floor, wait until the job is completed to use oil absorbent materials to clean the floor

   _____2) Do not direct oil spray toward other workers

   _____3) Always have the proper container at hand to catch fuel, oil, or other fluids before attempting to drain them

   _____4) Pour old oil down the drain

   _____5) The best time to do a good oil job is when the machine or engine i running

   c. Eye protection — Always use safety goggles while performing the following operations or as required by state and school laws or policy:

   _____1) Grinding, chipping, or drilling

   _____2) Working under equipment

   _____3) Operating abrasive discs

   _____4) Charging batteries or using caustic cleaning compounds

TEST

d. Electrical

_____1) *Any* and *all* dangerous conditions of equipment should be reported to the instructor

_____2) Treat all electrical equipment as "live" until you have carefully checked

_____3) Use two wire cords and plugs to ground for all portable lights and tools

_____4) Check the condition of cords, plugs, and sockets

_____5) Eliminate cords and wires as trip hazards

_____6) Leave out tools and pieces of equipment where you finish work today so you can quickly resume work tomorrow

_____7) Be prepared to turn off any electrical power switch and/or main switch in case of emergency

e. Air pressure

_____1) Use compressed air equipment for dusting off clothing and work benches

_____2) *Never* use compressed oxygen in place of compressed air

_____3) Use compressed air only for the purpose for which it is intended and in a manner approved by OSHA

f. Equipment

_____1) Do not operate any machine without having been instructed in its use

_____2) Start an engine when *you* are ready and hope that everyone is in the clear

_____3) Never start an engine without knowing how to shut if off and being ready to do so if the need calls for it

_____4) Keep hands and clothing away from moving parts

_____5) Never run an engine in an inadequately ventilated place

_____6) Read and heed all notes and cautions

_____7) Read instructions thoroughly and follow them carefully

_____8) If you lack the proper tools or have doubts of your ability to do the job correctly, consult your instructor

_____9) Light your work area adequately

_____10) Wear reasonably tight fitting shorts or cutoffs while working in the shop

TEST

______11) Wear a necktie and loose fitting apparel to work in the shop

______12) Always disconnect and ground the wire from the spark plug before inspecting or repairing any mower, tiller, saw, or other equipment

______13) After reassembly be sure all parts, nuts, bolts, and screws are securely in place

g. Batteries

______1) Handle batteries with care and use a battery strap or carrier

______2) Always hold battery upright and set securely so there is no danger of spilling acid

______3) Disconnect the battery charger from the terminals before shutting off the machine, even though it may spark

______4) Wear protective clothing such as chemical goggles, rubber aprons, gloves, and boots while working in battery charging operations

______5) If acid splashes on you, flush immediately with plenty of water and notify instructor

______6) When mixing battery solutions, always pour water into acid

______7) Test a battery with a pair of pliers, between the terminals, if it is believed to be dead

______8) Prevent accidental short circuits by disconnecting and insulating grounded battery cable before working on equipment

______9) Use appropriate charging amperage when charging battery and remove all battery caps

______10) Charge a frozen battery

8. Complete the following list of statements concerning Consumer Product Safety Commission standards by correctly filling in the blanks.

a. The standard defines a "walk-behind lawnmower" as a grass cutting machine with a minimum cutting width of ____________ inches

b. The standard specifies performance requirements for most rotary lawnmowers manufactured or imported after ________________

c. Every affected rotary lawnmower must carry a ________________ label

d. A blade control system is required that stops the blade completely within ____________ seconds after release of control

TEST

e. The standard expressly applies to the ________________ and initial sale to consumers; it is silent with respect to service and repair of so-called "compliance" units

9. List the four general shop safety rules.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

10. Complete a student safety pledge form (Assignment Sheet #1).

11. Complete a student shop safety inspection checklist (Assignment Sheet #2).

SAFETY
UNIT I-A

ANSWERS TO TEST

1. a. 10
   b. 4
   c. 1
   d. 5
   e. 9
   f. 7
   g. 8
   h. 2
   i. 6
   j. 3

2. a. 4
   b. 6
   c. 1
   d. 3
   e. 5
   f. 2

3. a. Ease in cleaning
   b. Stack
   c. Cabinets
   d. Hazards
   e. Slippery
   f. Exits
   g. Combustible
   h. Metal
   i. Orderly
   j. Housekeeping

4. a. 2
   b. 1
   c. 3
   d. 4

5. a. Fuel
   b. Heat
   c. Oxygen

6. a. 2, 3, and 4
   b. 2 and 3
   c. 1 and 4
   d. 3

7. a. 1) S
      2) S
      3) U
      4) U
      5) S
      6) S
      7) U
      8) S

   b. 1) U
      2) S
      3) S
      4) U
      5) U

ANSWERS TO TEST

c.
- 1) S
- 2) S
- 3) S
- 4) S

d.
- 1) S
- 2) S
- 3) U
- 4) S
- 5) S
- 6) U
- 7) S

e.
- 1) U
- 2) S
- 3) S

f.
- 1) S
- 2) U
- 3) S
- 4) S
- 5) S
- 6) S
- 7) S
- 8) S
- 9) S
- 10) U
- 11) U
- 12) S
- 13) S

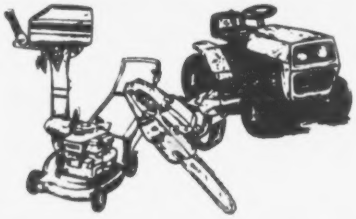
g.
- 1) S
- 2) S
- 3) U
- 4) S
- 5) S
- 6) U
- 7) U
- 8) S
- 9) S
- 10) U

8.
- a. 12
- b. June 30, 1982
- c. Certification
- d. Three
- e. Manufacturer

9.
- a. All injuries should be treated at once
- b. Safety equipment and shoes should be used and worn as required
- c. Running and horseplay are not permitted in the shop at any time
- d. *Any* and *all* dangerous conditions or damaged equipment should be reported to the instructor

10. Evaluated according to standards identified by the instructor

11. Evaluated according to standards identified by the instructor



Tools
Unit II-A

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify tools used for small engine repair. Competency will be demonstrated by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Identify the basic hand tools needed for maintenance and repair of small engines.
2. Identify the tools used for overhaul of small engines.
3. Identify the types of torque wrenches.
4. Complete a list of statements concerning maintenance procedures for tools.

TOOLS
UNIT II-A

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Integrate the following activities throughout the teaching of this unit:

1. Show students actual tools then test them on their ability to identify them.
2. Furnish tool catalogs with prices so that students can estimate the cost of furnishing a small engine repair shop.
3. Demonstrate the use and maintenance of tools.
4. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement of the unit.

H. Give test.

I. Evaluate test.

J. Reteach if necessary.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

SUGGESTED ACTIVITIES

C. Information sheet

D. Transparency masters

  1. TM 1 — Basic Hand Tools
  2. TM 2 — Basic Hand Tools (Continued)
  3. TM 3 — Basic Hand Tools (Continued)
  4. TM 4 — Basic Hand Tools (Continued)
  5. TM 5 — Basic Hand Tools (Continued)
  6. TM 6 — Overhaul Tools
  7. TM 7 — Overhaul Tools (Continued)
  8. TM 8 — Overhaul Tools (Continued)
  9. TM 9 — Overhaul Tools (Continued)
  10. TM 10 — Torque Wrenches

E. Test

F. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. American Association for Vocational Instructional Materials. *Small Engines Volume 1 and 2.* Athens, Georgia: AAVIM, 1974.

B. Bear, W. Forrest and Thomas A. Hoerner. *Torque and Torque Wrenches.* St. Paul, Minnesota: Hobar Publications, 1971.

C. Crouse, William H. and Donald L. Anglin. *Small Engine Mechanics.* Second Edition. New York: Gregg Division, McGraw-Hill Book Company, 1980.

D. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

TOOLS
UNIT II-A

INFORMATION SHEET

I. **Basic hand tools needed for maintenance and repair (Transparencies 1, 2, 3, 4, and 5)**

A. Basic hand tool assortment

1. Hammers

   a. Ball peen - one pound

   b. Soft face

2. Screwdrivers

   a. Standard slot type

      1) 4 inch

      2) 1 ½ inch

      3) 6 inch

      4) 8 inch

   b. Phillips

      1) 1 ½ inch

      2) 6 inch

      3) 8 inch

   c. Offset

   d. Clutch head

3. Pliers

   a. Slip joint

   b. Diagonal cutting

   c. Lock ring

   d. Needle nose

INFORMATION SHEET

   - e. Snap ring
   - f. Vise grip
4. Wrenches
   - a. Adjustable
   - b. Hex set including 5/64" to 1/4"

     (NOTE: This is also called an allen wrench.)
   - c. Open-end set including 3/8", 7/16", 1/2", 5/8", and 9/16"
   - d. Torque — Inch pound 3/8" drive
   - e. Combination set 7/16" to 7/8"
   - f. Open-end set — Metric
5. Center punch
6. Cold chisel
7. Universal joint
8. Reversible ratchets
   - a. 3/8" drive
   - b. 1/4" drive
9. Socket sets
   - a. 3/8" drive standard
   - b. 1/4" drive standard
   - c. 3/8" drive metric
   - d. Spark plug deep — 13/16" by 3/8" drive and 3/4" by 3/8"
10. Feeler gauges
    - a. Flat
    - b. Wire
11. File

INFORMATION SHEET

12. Parts scraper
13. Clutch wrench — Clutch wrench

B. Other tools

1. Battery clamp puller
2. Battery hydrometer
3. Battery post cleaner
4. Battery syringe
5. Parts cleaning brush
6. Wire brush
7. Parts washing container
8. Funnel
9. Flywheel holder
10. Ignition wrench set
11. Thread repair insert

II. **Standard overhaul tools (Transparencies 6, 7, 8, and 9)**

A. Boring bar

B. Piston ring expander

C. Piston ring groove cleaner

D. Keeper retainer

E. Punch and chisel set

F. Ridge reamer

G. Ring compressor

H. Ring groove gauge

I. Twist drill bit

J. Valve grinder

INFORMATION SHEET

K. Valve lapping tools
    1. Wood handle
    2. Crank handle

L. Valve seat cutters
    1. Manual
    2. Power

M. Valve spring compressor
    1. Small engine
    2. Lever type

N. Telescoping gauge

O. Valve guide reamer

P. Pullers
    1. Bearing
    2. Flywheel

Q. Precision hone

R. Deglazer

III. Types of torque wrenches (Transparency 10)

A. Signaling

(NOTE: This is a click type wrench which signals to the operator when the correct torque is reached.)

B. Direct reading

(NOTE: The torque is read directly from a dial indicator or on a scale from a pointer.)

C. Dial indicator

INFORMATION SHEET

IV. Maintenance procedures for tools

A. Screwdrivers

1. Regrind worn or damaged flat blade screwdrivers
2. Discard phillips screwdrivers with damaged heads

B. Pliers

1. Keep pliers clean and rust free
2. Keep cutting edges sharp and smooth
3. Keep pliers working freely
4. Repair or replace damaged handle insulation

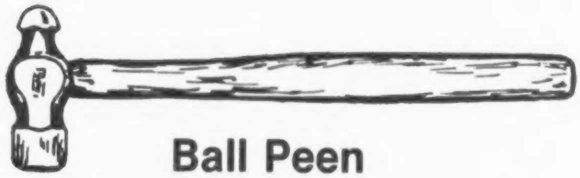
C. Adjustable wrench — Keep worm gears clean and lubricated

D. All tools — Identify tools by labeling them with an electric pencil or scratch awl

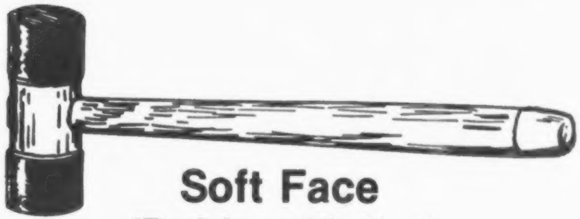
(NOTE: An identification mark can help you distinguish between your tools and someone elses.)

Basic Hand Tools

Hammers

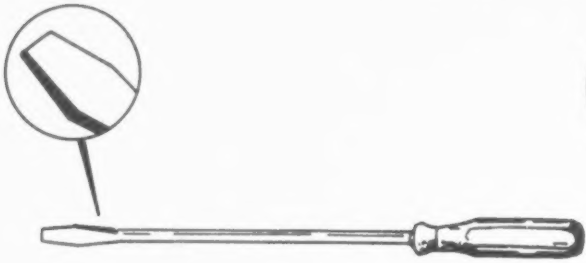


Ball Peen

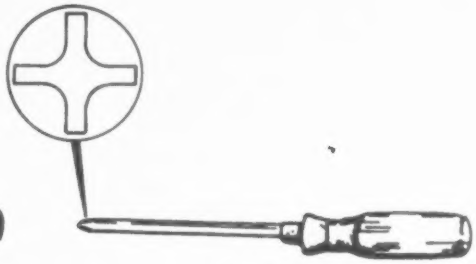


Soft Face
(Rubber Mallet)

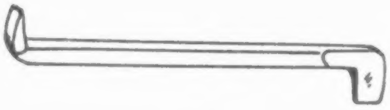
Screwdrivers



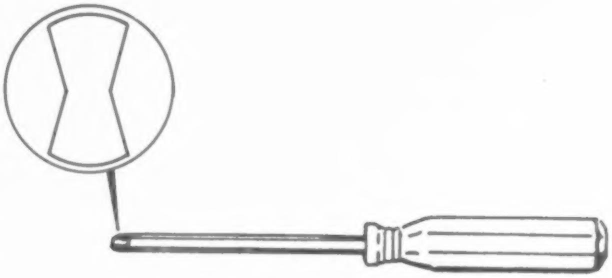
Standard Slot Type



Phillips



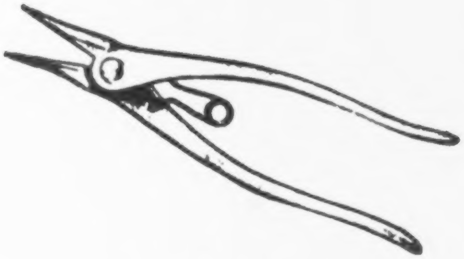
Offset



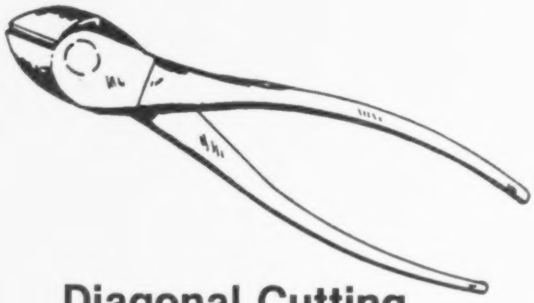
Clutch Head

Basic Hand Tools (Continued)

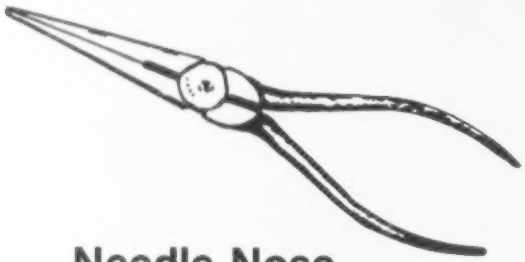
Pliers



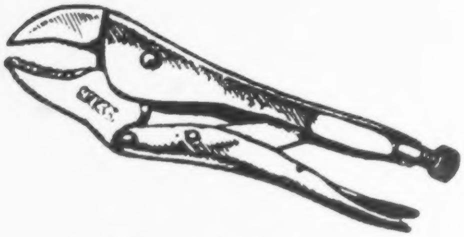
Lock Ring



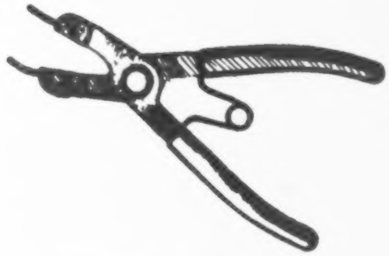
Diagonal Cutting



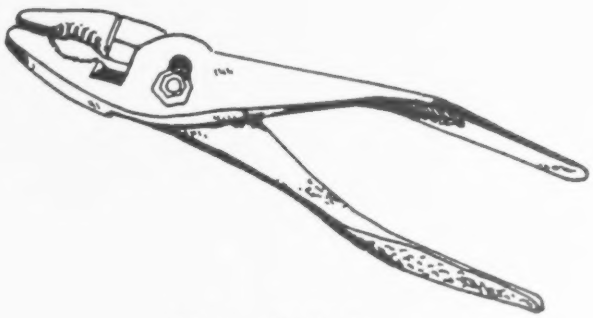
Needle Nose



Vise Grip



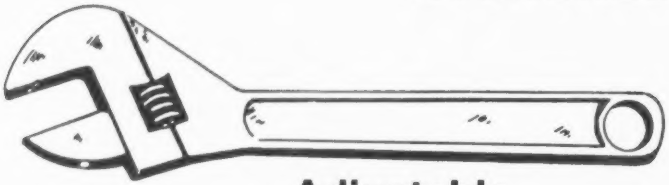
Snap Ring



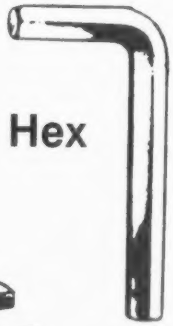
Slip Joint

Basic Hand Tools (Continued)

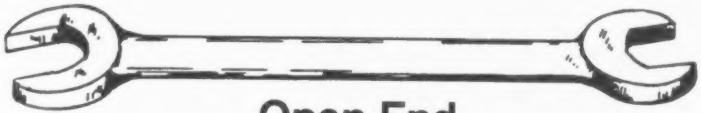
Wrenches



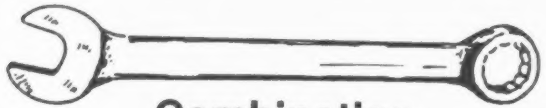
Adjustable



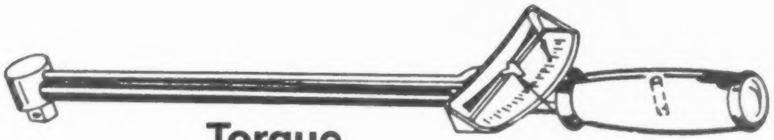
Hex



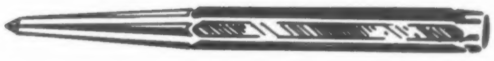
Open-End



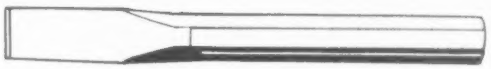
Combination



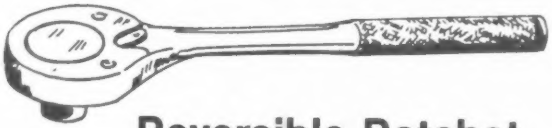
Torque



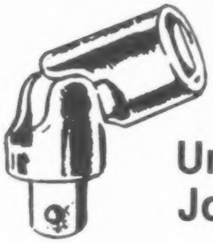
Center Punch



Cold Chisel

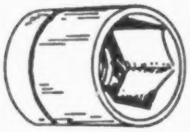


Reversible Ratchet

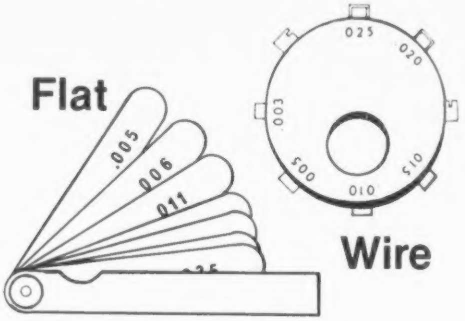


Universal
Joint

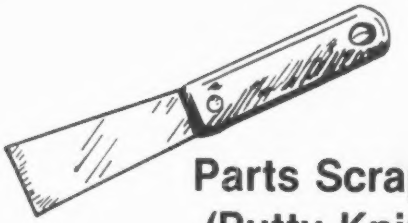
Basic Hand Tools (Continued)



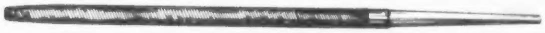
Socket


Flat
.005
.006
.011
.025
Wire
025
020
015
010
005
003

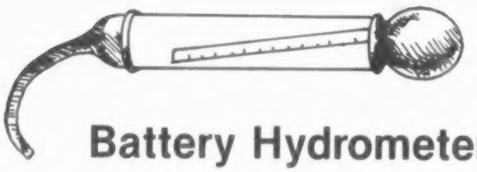
Feeler Gauges



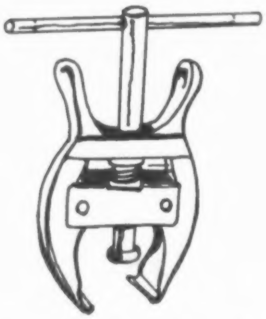
Parts Scraper (Putty Knife)



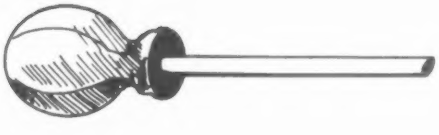
File



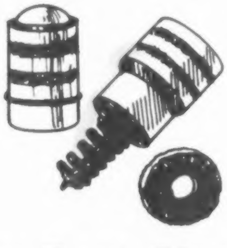
Battery Hydrometer



Battery Clamp Puller

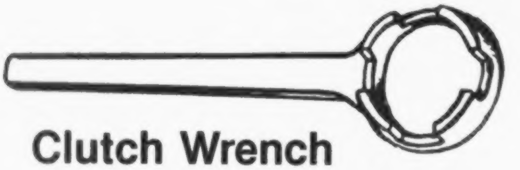


Battery Syringe

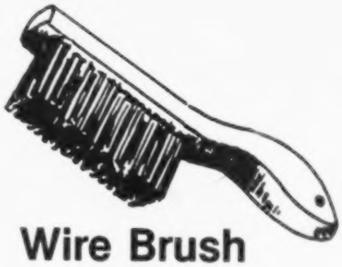


Battery Post Cleaner

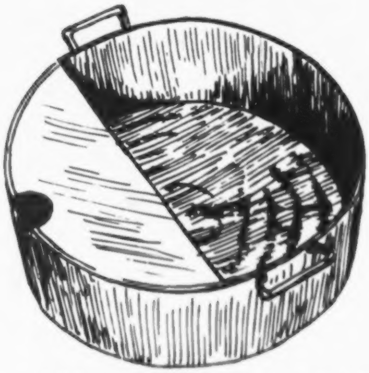
Basic Hand Tools
(Continued)



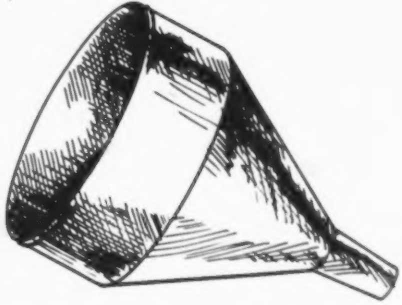
Clutch Wrench



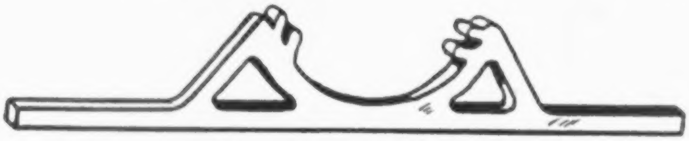
Wire Brush



Parts Washing Container

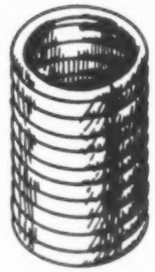


Funnel

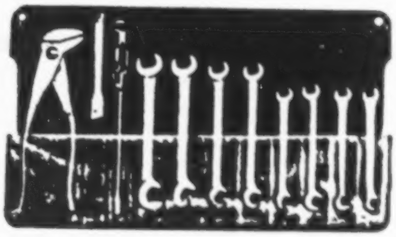


Flywheel Holder

Parts Cleaning Brush

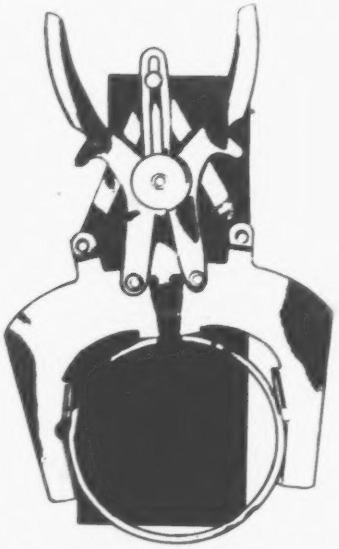


Thread Repair Insert

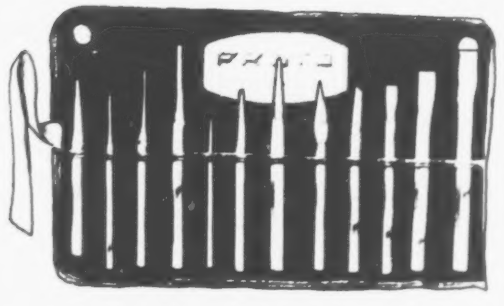


Ignition Wrench Set

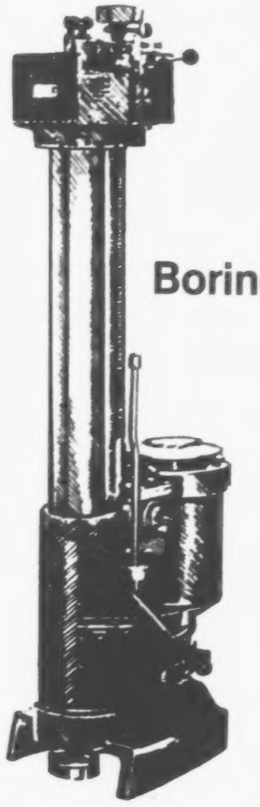
Overhaul Tools



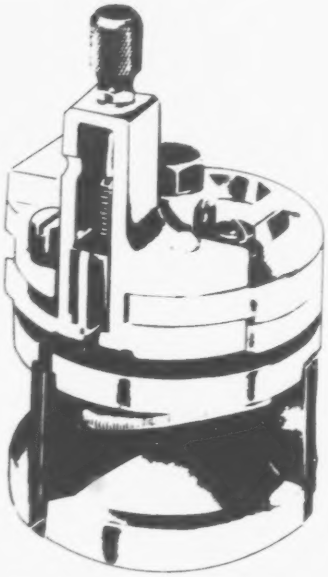
Piston Ring Expander



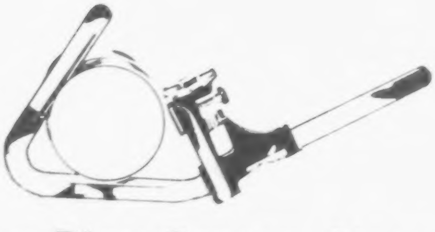
Punch and Chisel Set



Boring Bar

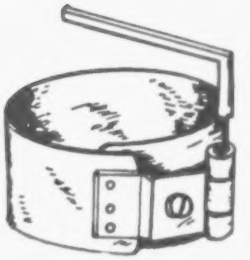


Ridge Reamer

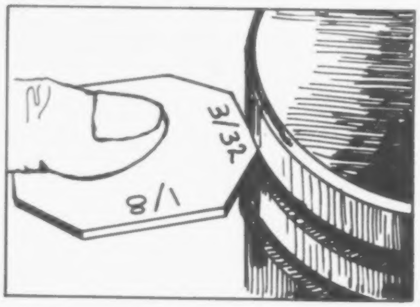


Piston Ring Groove Cleaner

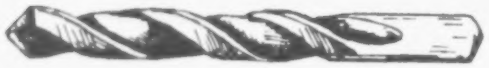
Overhaul Tools (Continued)



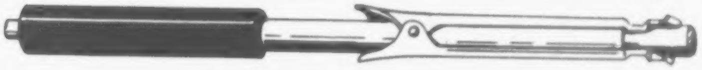
Ring Compressor



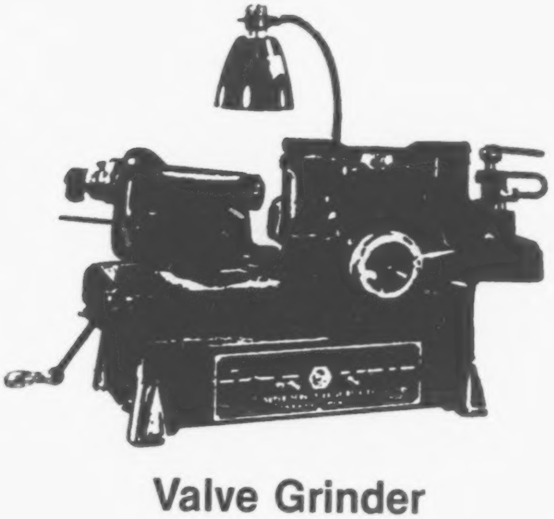
Ring Groove Gauge



Twist Drill Bit



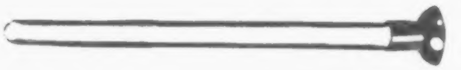
Keeper Retainer



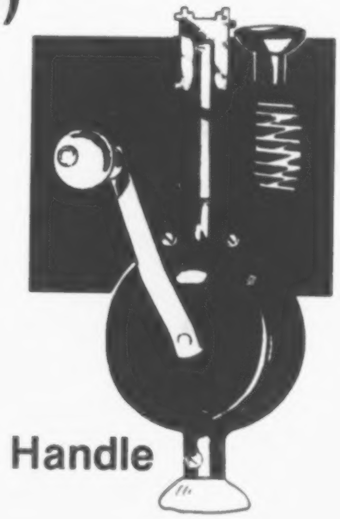
Valve Grinder

Overhaul Tools (Continued)

Valve Lapping Tool

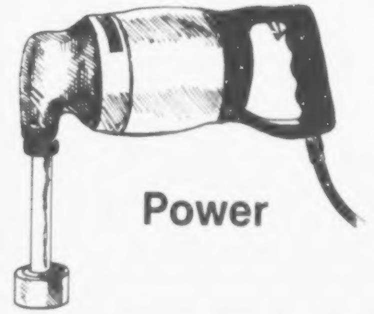


Wood Handle

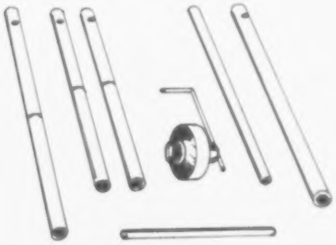


Crank Handle

Valve Seat Cutter

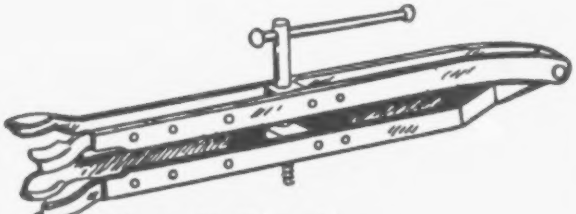


Power

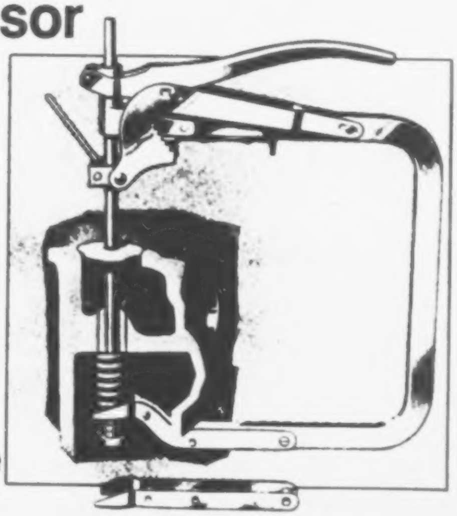


Manual

Valve Spring Compressor

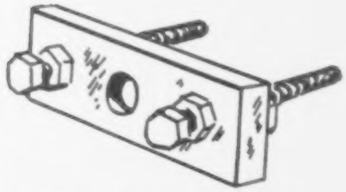


Small Engine

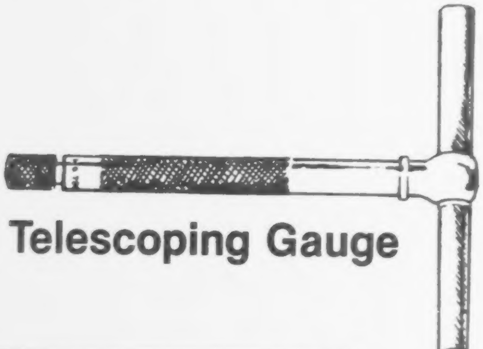


Lever Type

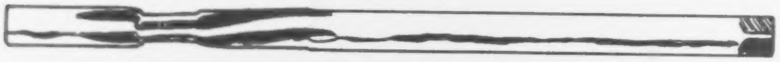
Overhaul Tools (Continued)



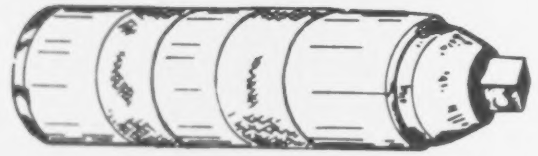
Flywheel Puller



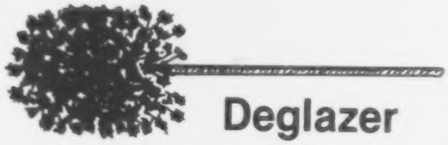
Telescoping Gauge



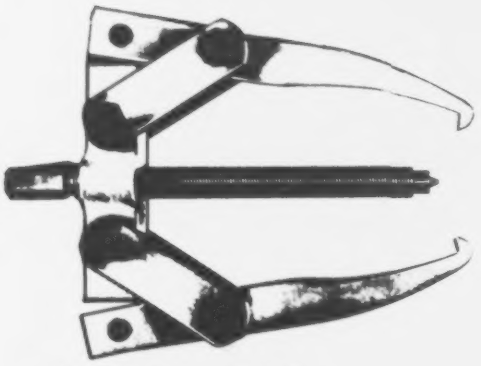
Valve Guide Reamer



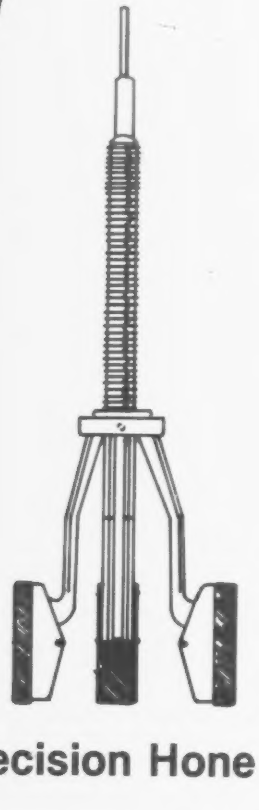
Impact Driver



Deglazer

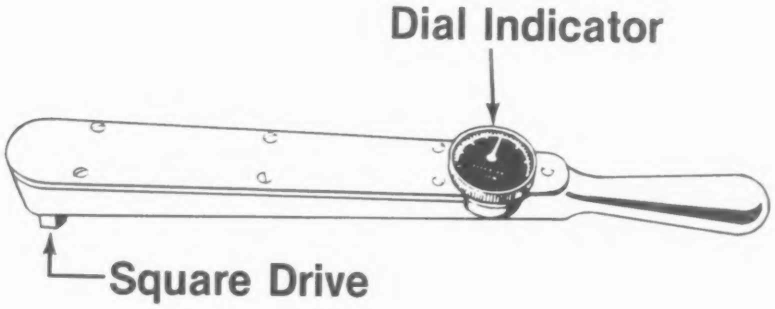


Bearing Puller

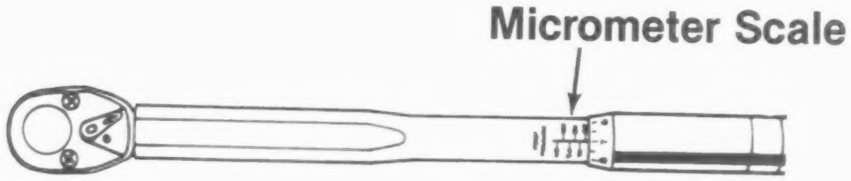


Precision Hone

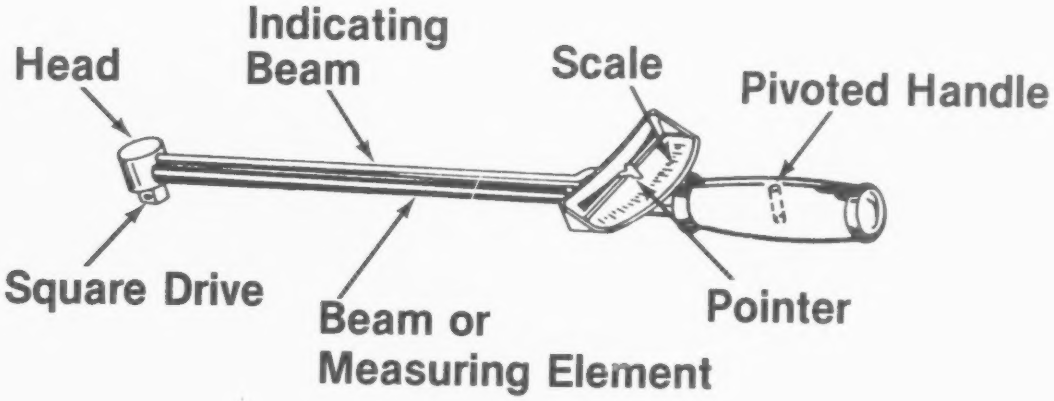
Torque Wrenches


Dial Indicator
Square Drive

Dial Indicator


Micrometer Scale

Signaling


Head
Indicating Beam
Scale
Pivoted Handle
Square Drive
Beam or Measuring Element
Pointer

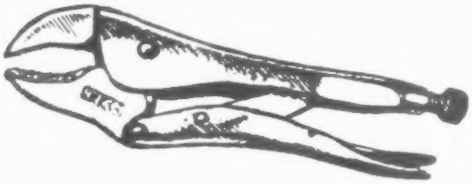
Direct Reading

TOOLS
UNIT II-A

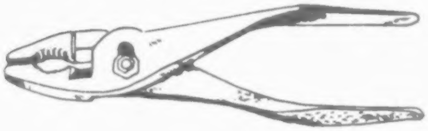
NAME ______________________

TEST

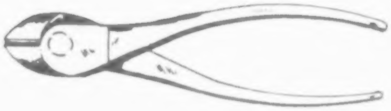
1. Identify the basic hand tools needed for maintenance and repair of small engines.



a. ______________________

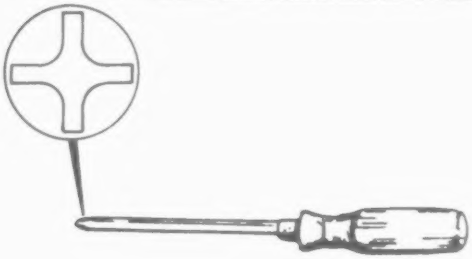


b. ______________________



c. ______________________

d. ______________________



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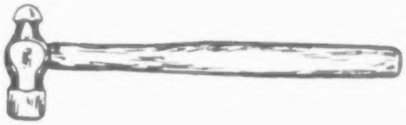

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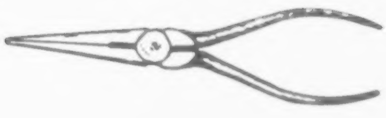

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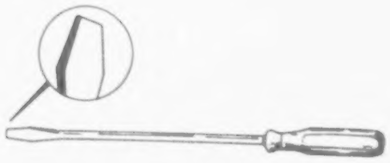

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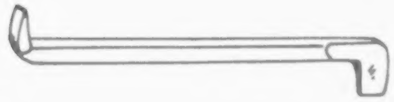

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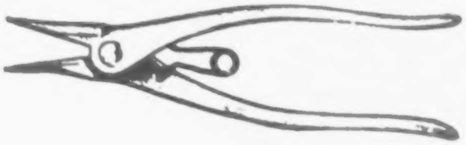

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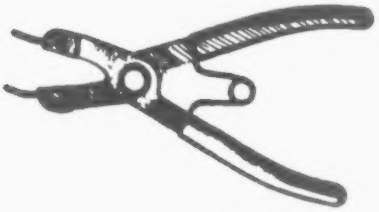

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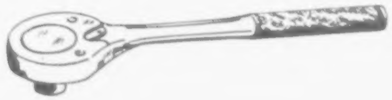

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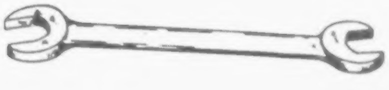

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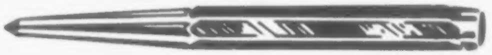

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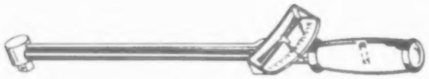

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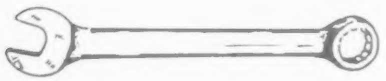

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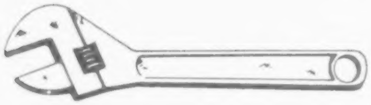

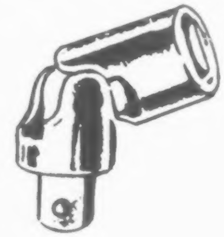

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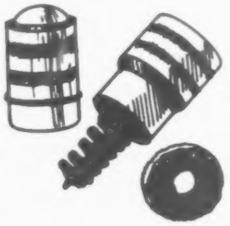

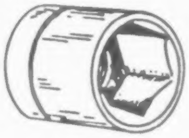

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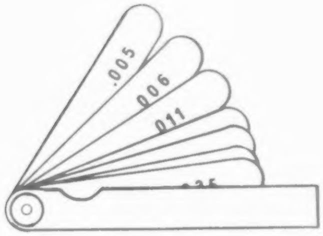
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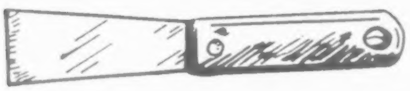

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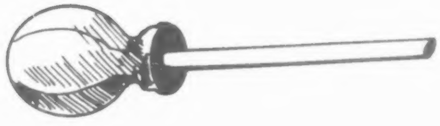

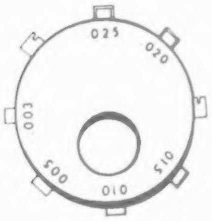
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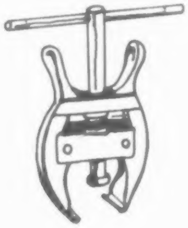

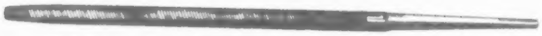

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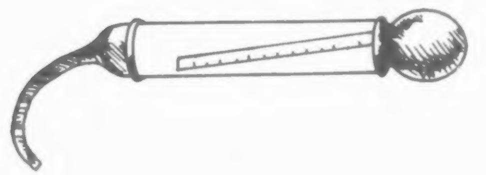

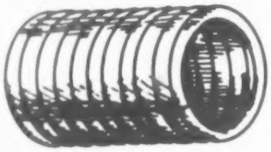

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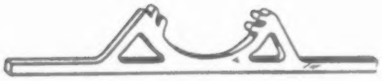

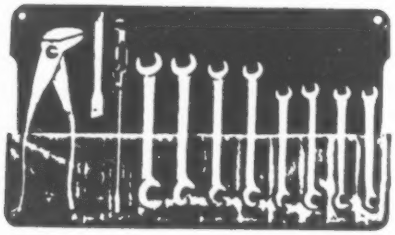

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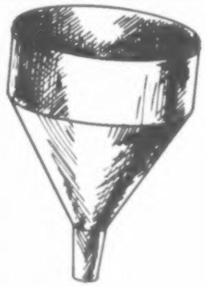

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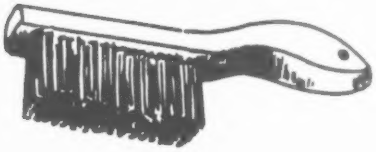

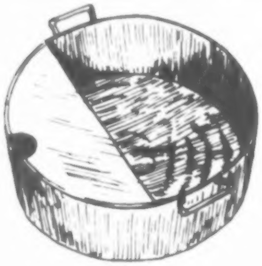

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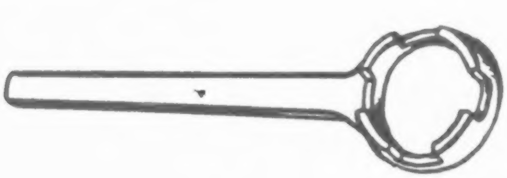
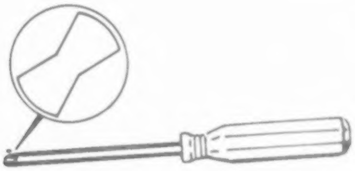


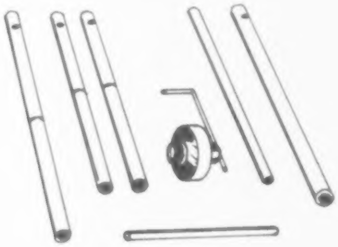


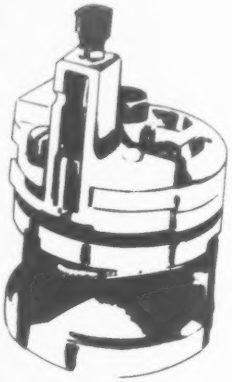
kk. ______________________

ll. ______________________

TEST

2. Identify the tools used for overhaul of small engines.





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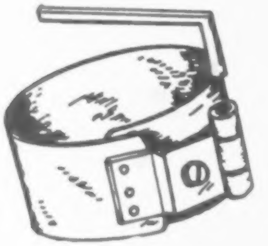

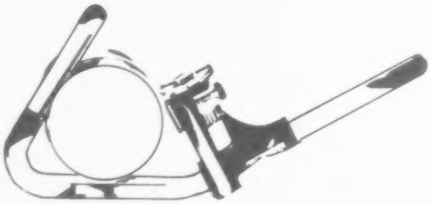

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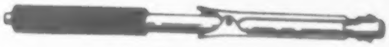
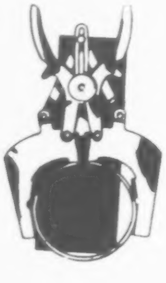
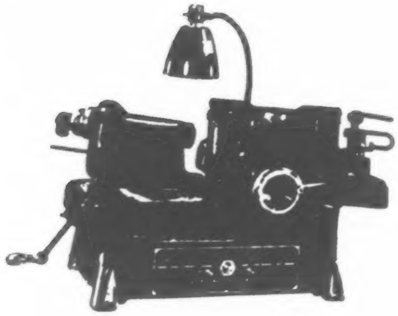
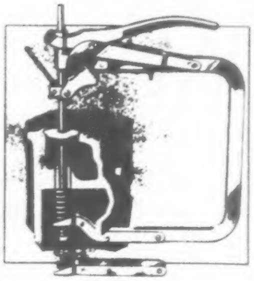




e. ______________________ f. ______________________

TEST





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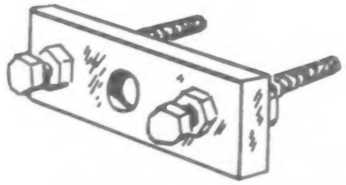

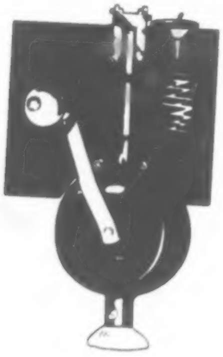

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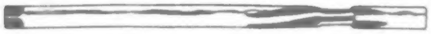

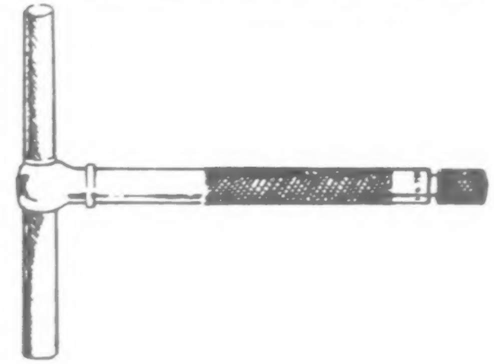

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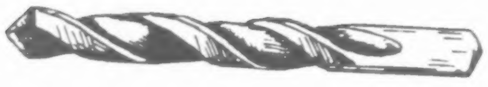
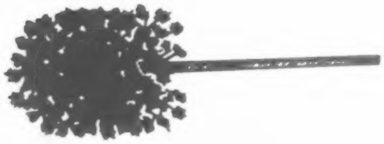
TEST





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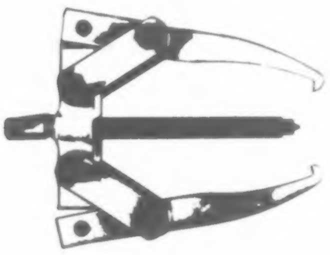

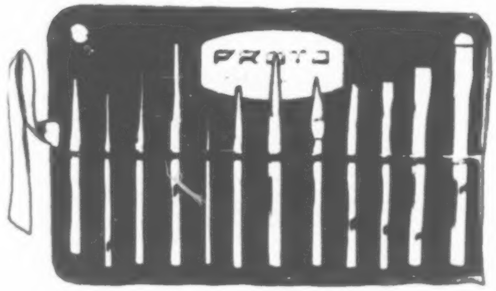

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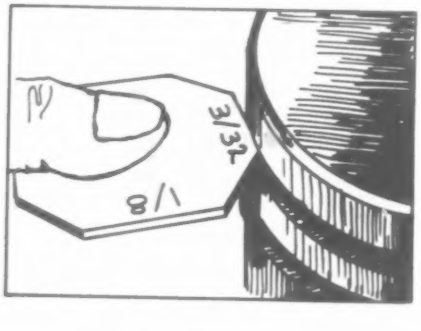

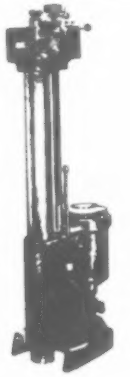

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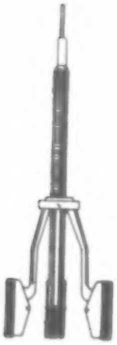
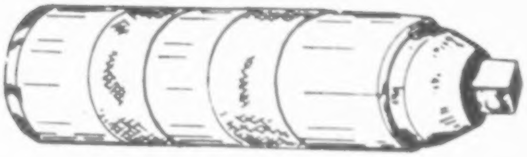
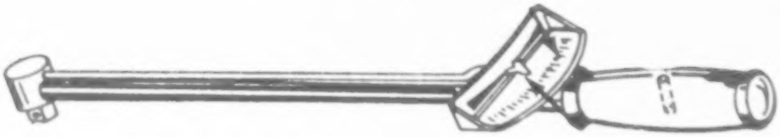




s. ______________________ t. ______________________

3. Identify the types of torque wrenches.



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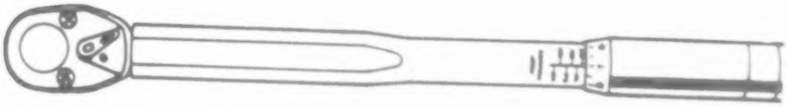

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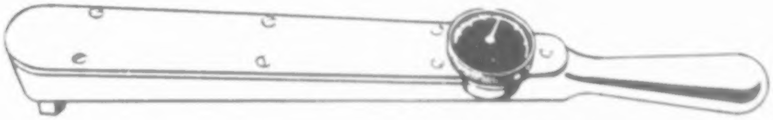


c. ______________________

TEST

4. Complete the following list of statements concerning maintenance procedures for tools by correctly filling in the blanks.

   a. ________________ worn or damaged flat blade screwdrivers

   b. Discard phillips screwdrivers with damaged ________________

   c. Keep pliers clean and ________________

   d. Repair or replace damaged handle ________________

   e. On adjustable wrenches, keep worm gears clean and ________________

   f. Identify all tools by labeling them with an electric pencil or ________________ ________________

TOOLS
UNIT II-A

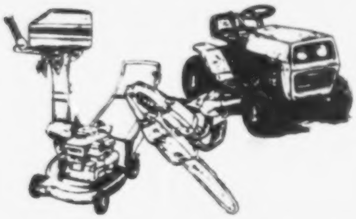
ANSWERS TO TEST

1. a. Vise grip pliers
   b. Slip joint pliers
   c. Diagonal cutting pliers
   d. Soft face hammer
   e. Phillips screwdriver
   f. Ball peen hammer
   g. Needle nose pliers
   h. Standard slot type screwdriver
   i. Offset screwdriver
   j. Lock ring pliers
   k. Snap ring pliers
   l. Reversible ratchet
   m. Open-end wrench
   n. Center punch
   o. Cold chisel
   p. Torque wrench
   q. Combination wrench
   r. Hex wrench
   s. Adjustable wrench
   t. Universal joint
   u. Battery post cleaner
   v. Socket
   w. Feeler gauge — flat
   x. Parts scraper
   y. Battery syringe
   z. Feeler gauge — wire
   aa. Battery clamp puller
   bb. File
   cc. Battery hydrometer
   dd. Thread repair insert
   ee. Flywheel holder
   ff. Ignition wrench set
   gg. Parts cleaning brush
   hh. Funnel
   ii. Wire brush
   jj. Parts washing container
   kk. Clutch wrench
   ll. Clutch head screwdriver

2. a. Manual valve seat cutter
   b. Ridge reamer
   c. Ring compressor
   d. Piston ring groove cleaner
   e. Keeper retainer
   f. Piston ring expander
   g. Valve grinder
   h. Lever type valve spring compressor
   i. Flywheel puller
   j. Valve lapping tool
   k. Valve guide reamer
   l. Telescoping gauge
   m. Twist drill bit
   n. Deglazer
   o. Bearing puller
   p. Punch and chisel set
   q. Ring groove gauge
   r. Boring bar
   s. Precision hone
   t. Impact driver

3. a. Direct reading
   b. Signaling
   c. Dial indicator

4. a. Regrind
   b. Heads
   c. Rust free
   d. Insulation
   e. Lubricated
   f. Scratch awl



Fasteners
Unit III-A

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify typical fasteners and select qualities of satisfactory fasteners. The student should also be able to select methods used to remove seized nuts and repair damaged threads using a thread repair kit. Competencies will be demonstrated by correctly performing the procedure outlined in the job sheet and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to fasteners with their correct definitions.
2. Select qualities of satisfactory fasteners.
3. Identify typical fasteners.
4. Identify typical bolt head styles.
5. Complete a list of statements concerning how bolt sizes, lengths, and threads are measured.
6. Select true statements concerning SAE grade and metric bolts.
7. Identify typical nuts.
8. Identify special purpose nuts with locking or self-locking features.
9. Select methods used to remove a seized nut.

OBJECTIVE SHEET

10. Identify five types of washers.
11. Select tools used to restore bolt threads.
12. Select tools used to restore internal threads.
13. List four devices for locking nuts or bolts.
14. Identify types of machine screw head designs.
15. Identify four types of snap rings.
16. Demonstrate the ability to repair damaged threads using a thread repair kit (Job Sheet #1).

FASTENERS
UNIT III-A

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheet prior to the demonstration of the procedure.

H. Integrate the following activities throughout the teaching of this unit:

1. Show students examples of the various types of fasteners and discuss their uses.
2. Have students sort various nuts and bolts.
3. Have students size different threads.
4. Show students various breaking points of different grade bolts.
5. Demonstrate and discuss the procedure outlined in the job sheet.
6. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

SUGGESTED ACTIVITIES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

    1. TM 1 — Typical Fasteners
    2. TM 2 — Bolt Head Styles
    3. TM 3 — How to Measure Bolts and Threads
    4. TM 4 — SAE Grade Marking for Steel Bolts and Screws
    5. TM 5 — Metric Bolt and Nut Identification
    6. TM 6 — Typical Nuts
    7. TM 7 — Special Purpose Nuts
    8. TM 8 — Methods Used to Remove a Seized Nut
    9. TM 9 — Types of Washers
    10. TM 10 — Tools Used to Restore Bolt Threads and Internal Threads
    11. TM 11 — Devices for Locking Nuts or Bolts
    12. TM 12 — Machine Screw Head Designs
    13. TM 13 — Types of Snap Rings

E. Job Sheet #1 — Repair Damaged Threads Using a Thread Repair Kit

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Fundamentals of Service: Fasteners*. Moline, Illinois: Deere and Company, 1979.

B. Foutes, William. *Diesel Mechanics: Fundamentals*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1982.

C. *Comprehensive Small Engine Repair*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

FASTENERS
UNIT III-A

INFORMATION SHEET

I. **Terms and definitions**

  A. Bolt — Metal rod or pin for fastening objects together that has a head at one end, a screw thread at the other end, and is secured by a nut

  B. Screw — Pointed and headed cylindrical fastener that is threaded and designed for insertion into material by rotating

  C. Fastener — Device used to secure or hold together separate items

  D. Tap — Tool for forming an internal screw thread

  E. Die — Internally threaded screw cutting tool used for forming external screw threads

  F. Stud — Steel rod with threads on both ends, to be screwed permanently into a fixed part at one end and receive a nut on the exposed end

  G. SAE — Society of Automotive Engineers

II. **Qualities of satisfactory fasteners**

  A. Strong

  B. Reusable

  C. Easy to remove

  D. Withstand vibration

  E. Long lasting

  F. Corrosion resistant

  G. Temperature resistant

III. **Typical fasteners (Transparency 1)**

  A. Hex head bolt

  B. Wing nut

  C. Stud

  D. Woodruff key

INFORMATION SHEET

- E. Cap screw
- F. Socket head bolt
- G. Tapping screw
- H. Tooth lock washer
- I. Rivet
- J. Bolt and nut
- K. Cotter pin
- L. Square key
- M. Flat washer
- N. Plow bolt
- O. Carriage bolt
- P. Castle nut
- Q. Lock washer
- R. Adhesive
- S. Lock pin
- T. Snap ring
- U. Machine screw
- V. Set screw
- W. Spring lock pin
- X. Locking nut
- Y. Clevis pin

IV. **Typical bolt head styles** (Transparency 2)

- A. Hex head bolt
- B. Hex socket head bolt
- C. Plow bolt

INFORMATION SHEET

D. Square head cap screw

E. 12-point head bolt

F. Askew head bolt

G. Carriage bolt

H. Hex flange screw

V. Measuring bolts and threads (Transparency 3)

A. Size of bolt is determined by measuring the diameter of the thread end

B. Length of bolt is determined by measuring the distance from bottom of the head to the end of the threads

(NOTE: Some carriage bolts with round, flat, tapered heads are measured from the top of the head to the end of the threads.)

C. Number of threads per inch is determined by measuring with a rule or a thread gauge

(NOTE: American National Standards established the unified screw thread standard. Course threads are U.S. standard and fine threads are S.A.E. threads.)

VI. SAE grade and metric bolts (Transparencies 4 and 5)

A. SAE grade and metric bolts are identified by markings on the heads of the bolt

B. SAE grade bolts use slashes for identification

Example: Grade 1 and 2 — No slashes
Grade 5 — Three slashes
Grade 7 — Five slashes
Grade 8 — Six slashes

C. Metric bolts use numbers for identification which correspond to bolt strength; increasing numbers represent increasing strength

VII. Typical nuts (Transparency 6)

A. Acorn

B. Castle

C. Spring

INFORMATION SHEET

- D. Wing
- E. Hex
- F. Flanged
- G. Lock
- H. Slotted
- I. Weld
- J. Panel
- K. Serrated
- L. Single thread
- M. Specialty

VIII. Special purpose nuts with locking or self-locking features (Transparency 7)

- A. Prevailing torque lock nut
- B. Plastic insert lock nut
- C. Jam nut
- D. Castle nut
- E. Slotted nut
- F. Wing nut
- G. Speed nut
- H. Anchor nut
- I. Chamfered nut
- J. Cap nut
- K. Flange-lock nut
- L. Pal nut

INFORMATION SHEET

IX. **Methods used to remove a seized nut (Transparency 8)**

A. Penetrating oil

B. Hacksaw

C. Nut splitter

D. Chisel

E. Gas torch

X. **Types of washers (Transparency 9)**

A. Flat washer

B. Lock washer

C. External toothed lock washer

D. Internal toothed lock washer

E. Countersunk external toothed washer

XI. **Tools used to restore bolt threads (Transparency 10)**

A. Rethreading tool

B. Thread restorer

C. Rethreading die

XII. **Tools to restore internal threads (Transparency 10)**

A. Internal thread chaser

B. Hand tap

XIII. **Devices for locking nuts or bolts (Transparency 11)**

A. Cotter pins

B. Lockwire

C. Flat metal locks

D. Lock ears

INFORMATION SHEET

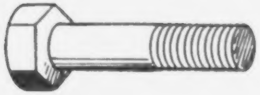
XIV. **Types of machine screw head designs (Transparency 12)**

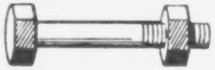
- A. Round
- B. Fillister
- C. Truss
- D. Pan
- E. Oval
- F. Cross recessed or phillips
- G. Flat
- H. Clutch
- I. Hex slotted

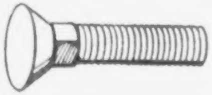
XV. **Types of snap rings (Transparency 13)**

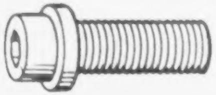
- A. Internal prong
- B. Internal hole
- C. External hole
- D. External "E"

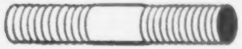
Typical Fasteners

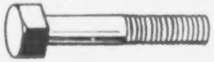

Hex Head Bolt

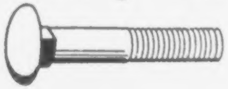

Bolt and Nut

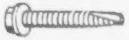

Plow Bolt

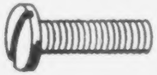

Socket Head Bolt

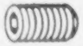

Stud

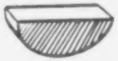

Cap Screw

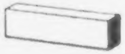

Carriage Bolt

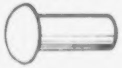

Tapping Screw

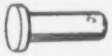

Machine Screw

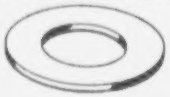

Set Screw

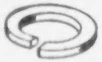

Woodruff Key

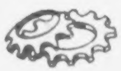

Square Key

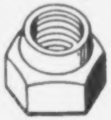

Rivet

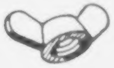

Clevis Pin

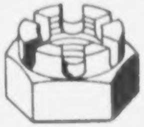

Flat Washer

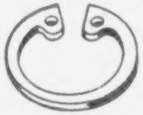

Lock Washer

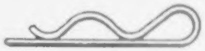

Toothed Lock Washer

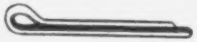

Locking Nut

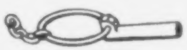

Wing Nut

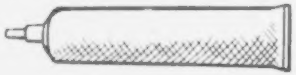

Castle Nut


Snap Ring


Spring Lock Pin


Cotter Pin

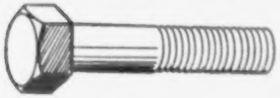

Lock Pin

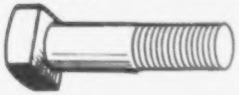

Adhesive

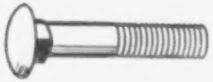
TM 1

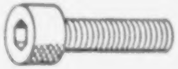
SE - 97-A

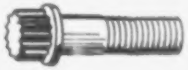
Bolt Head Styles

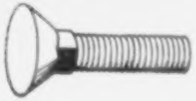

Hex Head Bolt

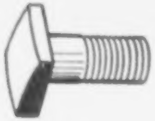

Square Head
Cap Screw

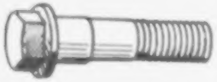

Carriage Bolt


Hex Socket Head Bolt

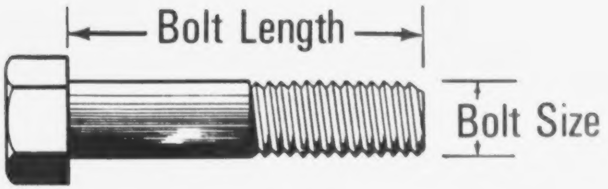

12-Point Head Bolt


Plow Bolt

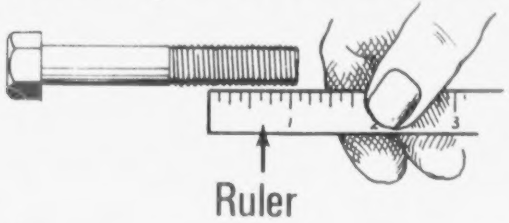

Askew Head Bolt

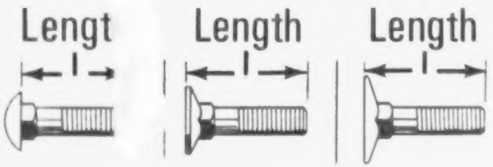

Hex Flange Screw

How to Measure Bolts and Threads

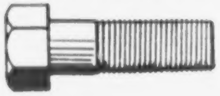

Bolt Length
Bolt Size

Measuring Threads Per Inch

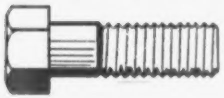



Lengt
Length
Length

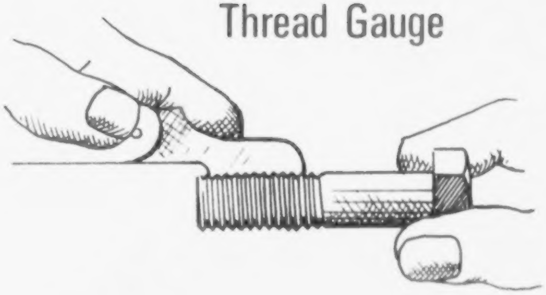
Fine Thread



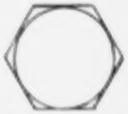
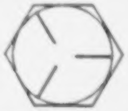
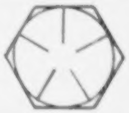
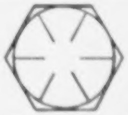
Coarse Thread



Thread Gauge

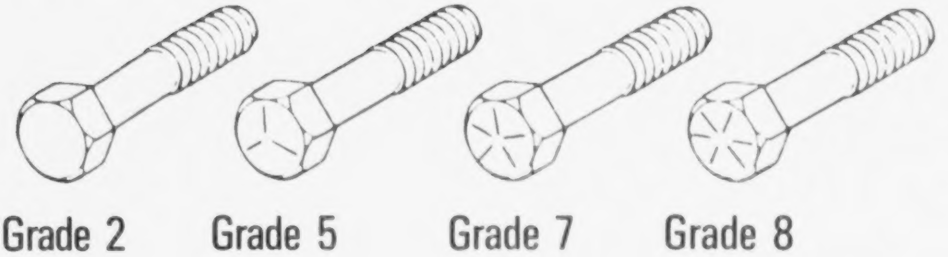


SAE Grade Markings For Steel Bolts and Screws

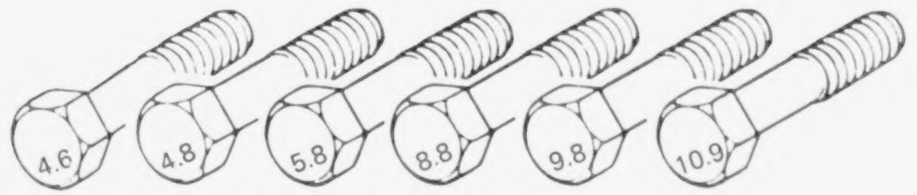
Grade Marking	Specification	Material	Tensile Strength min., psi.
	SAE-Grade 0	Steel	
	SAE-Grade 1	Low Carbon Steel	55,000
	SAE-Grade 2	Low Carbon Steel	69,000
	SAE-Grade 5	Medium Carbon Steel, Quenched and Tempered	120,000
	SAE-Grade 7	Medium Carbon Steel, Quenched and Tempered	133,000
	SAE-Grade 8	Med. Carbon Alloy Steel, Quenched and Tempered	150,000

Metric Bolt and Nut Identification

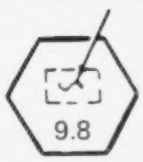
SAE Grade Bolts


Grade 2
Grade 5
Grade 7
Grade 8

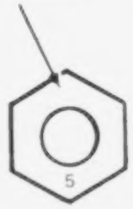
Metric Bolts


4.6
4.8
5.8
8.8
9.8
10.9

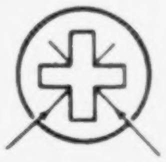
Manufacturer's Identification



Nut Strength Identification



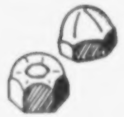
Posidriv Screw Head



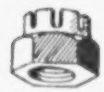
Identification Marks (4)

Typical Nuts

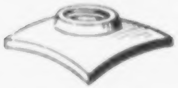
Acorn



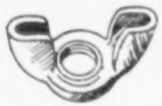
Castle



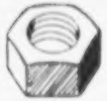
Spring



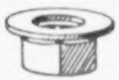
Wing



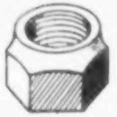
Hex



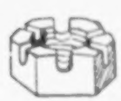
Flanged



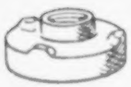
Lock



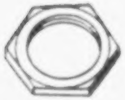
Slotted



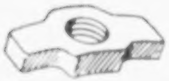
Weld



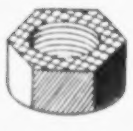
Panel



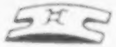
Specialty



Serrated

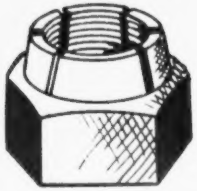


Single Thread

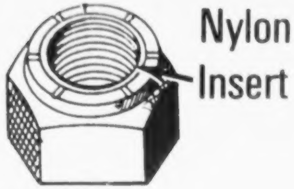


Special Purpose Nuts

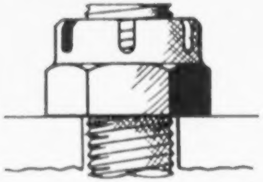
Prevailing Torque Lock Nut



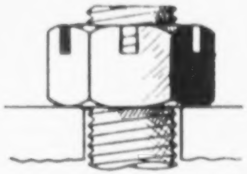
Plastic Insert Lock Nut



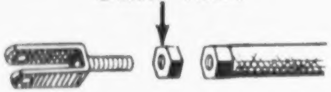
Castle Nut



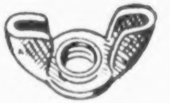
Slotted Nut



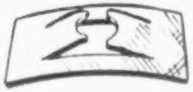
Jam Nut



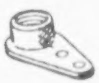
Wing Nut



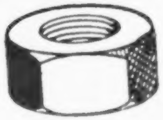
Speed Nut



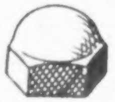
Anchor Nut



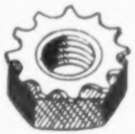
Chamfered Nut (Both Sides)



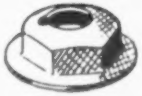
Cap Nut



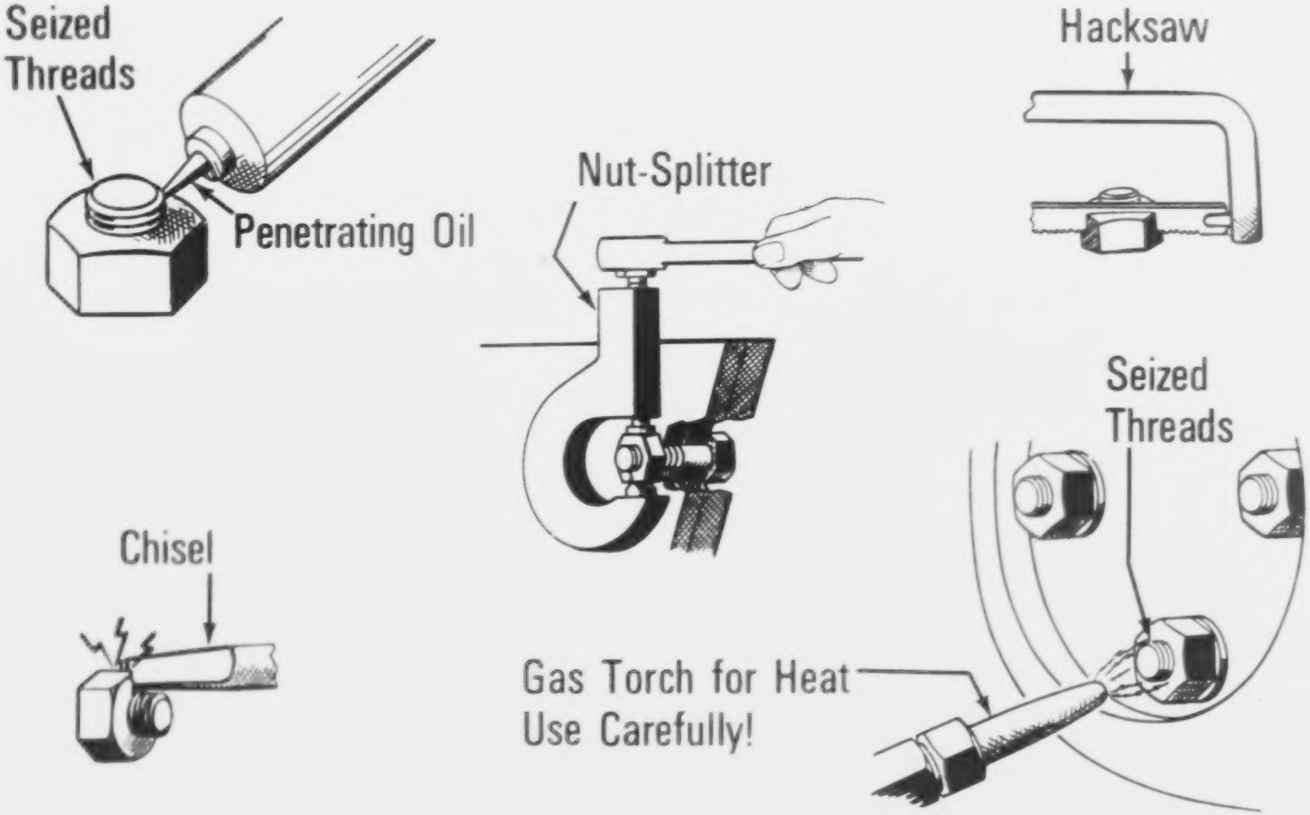
Flange-Lock Nut



Pal Nut

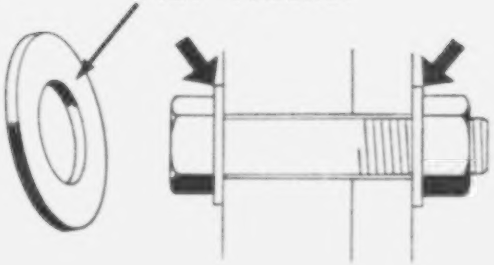


Methods Used to Remove a Seized Nut

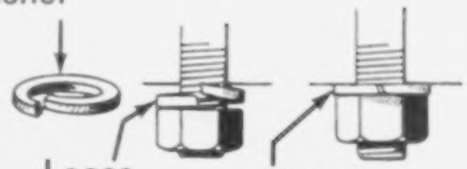

Seized Threads
Penetrating Oil
Nut-Splitter
Hacksaw
Seized Threads
Chisel
Gas Torch for Heat
Use Carefully!

Types of Washers

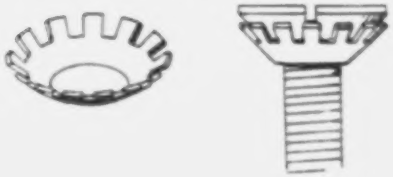
Flat Washer



Lock Washer

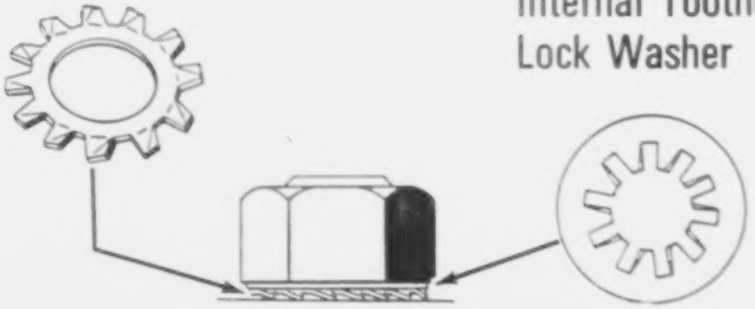

Loose
Tight
(Washer Grips)

Countersunk
External Toothed Washer



External Toothed
Lock Washer

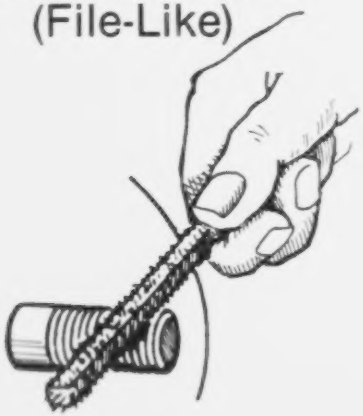
Internal Toothed
Lock Washer



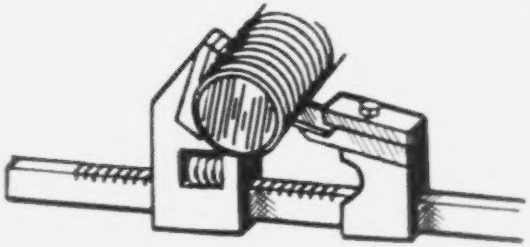
Tools Used to Restore Bolt Threads and Internal Threads

Bolt Threads

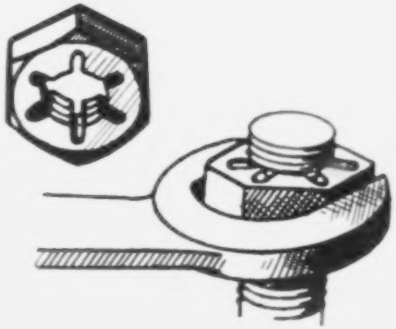
Thread Restorer
(File-Like)



Rethreading Tool

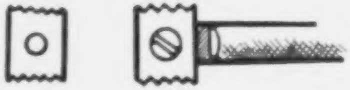


Rethreading
Die

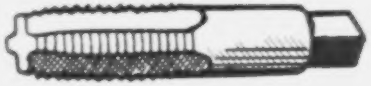


Internal Theads

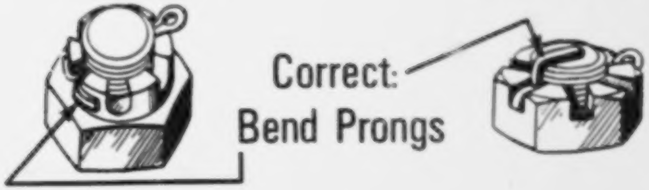
Internal Thread Chasers



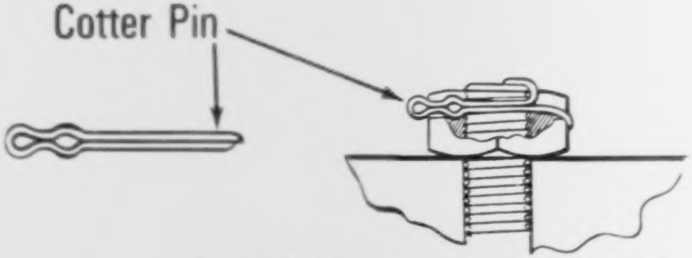
Hand Tap



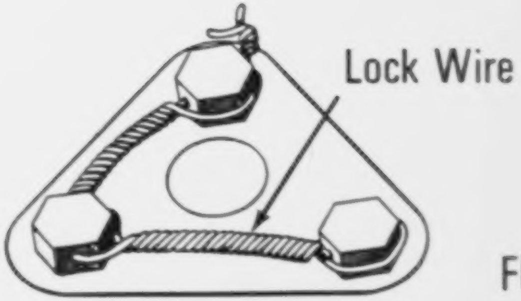
Devices for Locking Nuts or Bolts

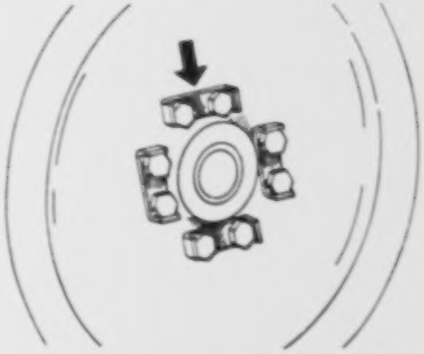

Castle Nut
Slotted Nut
Correct:
Bend Prongs

Cotter Pin Prongs Properly Bent Around Castle Nut and a Slotted Nut



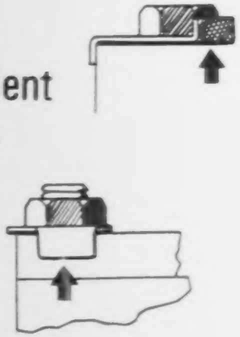
Double-Head Cotter Pin in Use





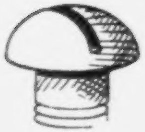
Flat Metal Locks Hold Flywheel Bolts in Place

Lock Ears Properly Bent Into Place

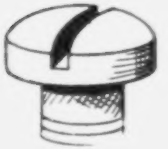


Machine Screw Head Designs

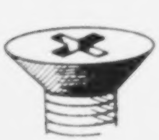
Round



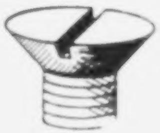
Fillister



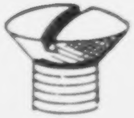
Cross Recessed
or Phillips



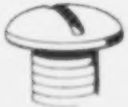
Flat



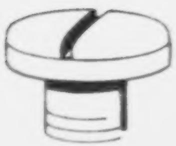
Oval



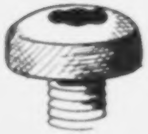
Truss



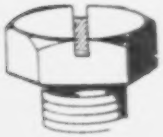
Pan



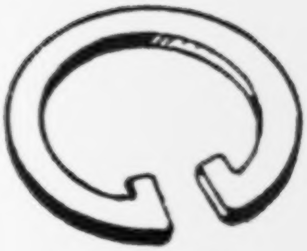
Clutch



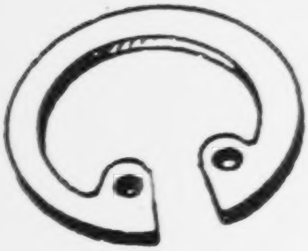
Hex Slotted



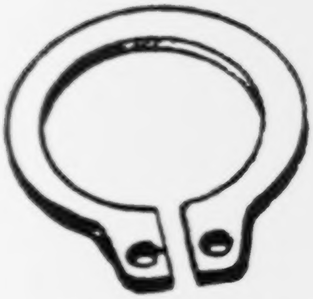
Types of Snap Rings



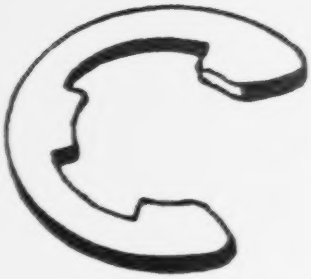
Internal Prong



Internal Hole



External Hole



External "E"

FASTENERS
UNIT III-A

JOB SHEET #1 — REPAIR DAMAGED THREADS USING A THREAD REPAIR KIT

A. Tools and materials needed

1. Safety glasses
2. Thread repair kit
3. Drill motor

B. Procedure

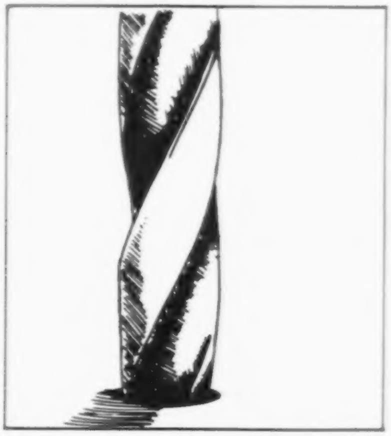
1. Drill out old threads using exact size drill (Figure 1)

   (NOTE: Refer to instructions provided in thread repair kit.)

2. Drill all the way through an open hole or all the way to bottom of blind hole

   (NOTE: Make sure hole is straight and that centerline of hole is not moved in drilling process.)

FIGURE 1

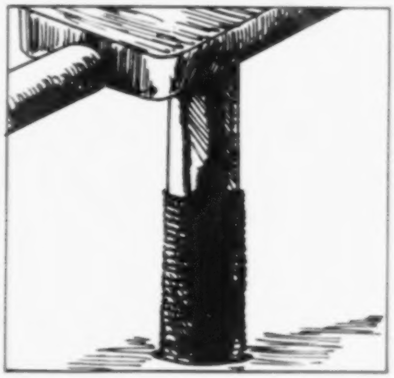


JOB SHEET #1

3. Tap out drilled holes (Figure 2)

   (NOTE: Special drill taps are provided in thread repair kit for threading drilled hole to correct size for outside of thread insert. A standard tap cannot be used.)

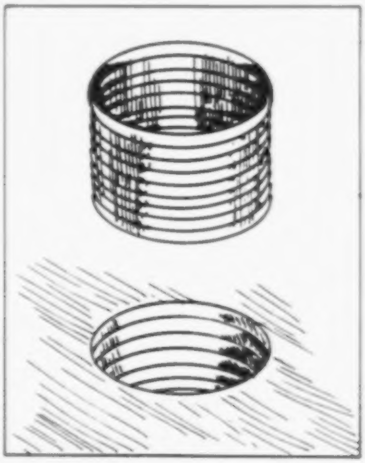
   FIGURE 2



4. Install thread repair insert using appropriate tool (Figure 3)

   (NOTE: Special tools are provided in thread repair kit for installation of thread insert.)

   FIGURE 3



5. Have instructor inspect work

6. Clean up work area and return tools to proper location

FASTENERS
UNIT III-A

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

______a. Metal rod or pin for fastening objects together that has a head at one end, and is secured by a nut

______b. Pointed and headed cylindrical fastener that is threaded and designed for insertion into material by rotating

______c. Device used to secure or hold together separate items

______d. Internally threaded screw cutting tool used for forming external screw threads

______e. Tool for forming an internal screw thread

______f. Steel rod with threads on both ends, to be screwed permanently into a fixed part at one end and receive a nut on the exposed end

______g. Society of Automotive Engineers

1. Tap
2. Stud
3. Screw
4. Die
5. Fastener
6. Bolt
7. SAE

2. Select qualities of satisfactory fasteners by placing an "X" in the appropriate blanks.

______a. Easy to remove

______b. Must be used with two washers

______c. Strong

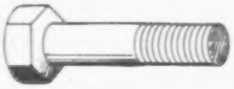
______d. Temperature resistant

______e. Be threaded on both ends

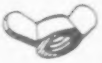
______f. Reusable

TEST

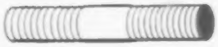
3. Identify typical fasteners.



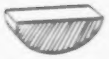
a. ______________________



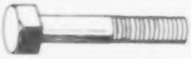
b. ______________________



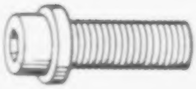
c. ______________________



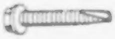
d. ______________________



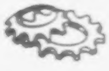
e. ______________________



f. ______________________



g. ______________________



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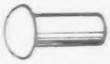
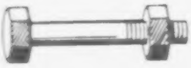
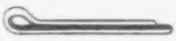


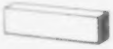
i. ______________________



j. ______________________

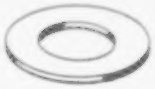


k. ______________________

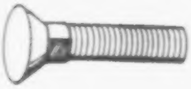


l. ______________________

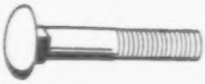
TEST



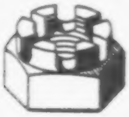
m. ______________________________



n. ______________________________



o. ______________________________



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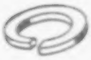

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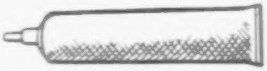
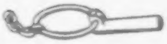
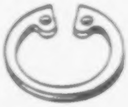


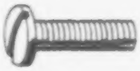
r. ______________________________



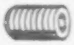
s. ______________________________



t. ______________________________

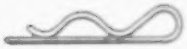


u. ______________________________

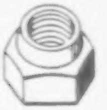


v. ______________________________

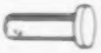
TEST



w. ____________________

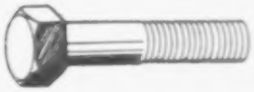


x. ____________________



y. ____________________

4. Identify typical bolt head styles.



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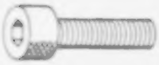

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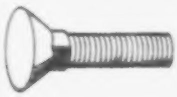

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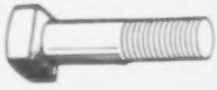

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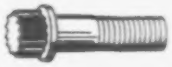

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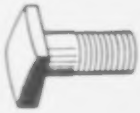
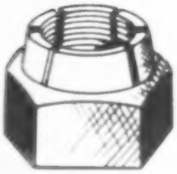


f. ____________________

TEST

8. Identify special purpose nuts with locking or self-locking features.



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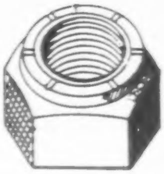

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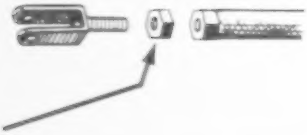

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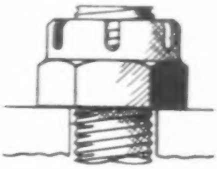

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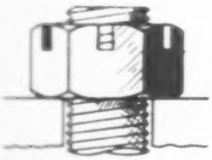

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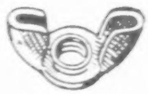

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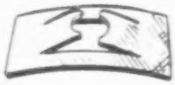
TEST



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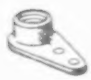

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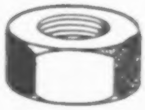

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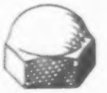

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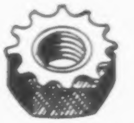

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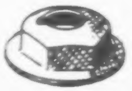


l. ______________________________

9. Select methods used to remove a seized nut by placing an "X" in the appropriate blanks.

______a. Hacksaw

______b. Chisel

______c. Gas torch

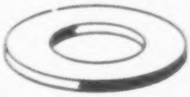
______d. Hot water

______e. Screwdriver

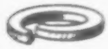
______f. Penetrating oil

TEST

10. Identify five types of washer.



a. ______________________



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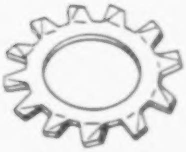
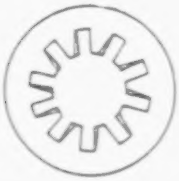
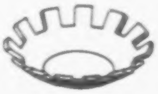


c. ______________________



d. ______________________



e. ______________________

11. Select tools used to restore bolt threads by placing an "X" in the appropriate blanks.

______a. Rethreading tap

______b. Rethreading die

______c. Rethreading tool

______d. Die stock

TEST

12. Select tools used to restore internal threads by placing an "X" in the appropriate blanks.

_____a. Threading die

_____b. Chisel

_____c. Hand tap

_____d. Internal thread chaser

13. List four devices for locking nuts or bolts.

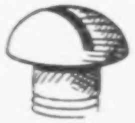
a. ______________________________

b. ______________________________

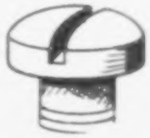
c. ______________________________

d. ______________________________

14. Identify types of machine screw head designs.



a. ______________________



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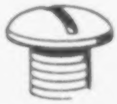

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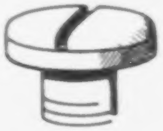

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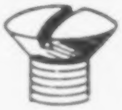

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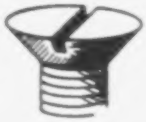
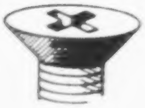
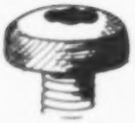


f. ______________________

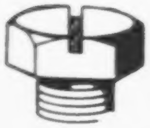
TEST



g. ______________________

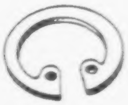


h. ______________________

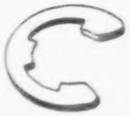


i. ______________________

15. Identify four types of snap rings.



a. ______________________



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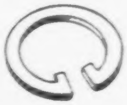
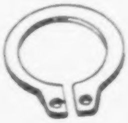


c. ______________________



d. ______________________

(NOTE: If the following activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

16. Demonstrate the ability to repair damaged threads using a thread repair kit (Job Sheet #1).

FASTENERS
UNIT III-A

ANSWERS TO TEST

1. a. 6
   b. 3
   c. 5
   d. 4
   e. 1
   f. 2
   g. 7

2. a,c,d,f

3. a. Hex head bolt
   b. Wing nut
   c. Stud
   d. Woodruff key
   e. Cap screw
   f. Socket head bolt
   g. Tapping screw
   h. Tooth lock washer
   i. Rivet
   j. Bolt and nut
   k. Cotter pin
   l. Square key
   m. Flat washer
   n. Plow bolt
   o. Carriage bolt
   p. Castle nut
   q. Lock washer
   r. Adhesive
   s. Lock pin
   t. Snap ring
   u. Machine screw
   v. Set screw
   w. Spring lock pin
   x. Locking nut
   y. Clevis pin

4. a. Hex head bolt
   b. Hex socket head bolt
   c. Plow bolt
   d. Square head cap screw
   e. 12-point head bolt
   f. Askew head bolt
   g. Carriage bolt
   h. Hex flange screw

5. c. Number of threads per inch is determined by measuring with a rule or a thread gauge

6. a

ANSWERS TO TEST

7. a. Castle
   b. Spring
   c. Wing
   d. Hex
   e. Flanged
   f. Lock
   g. Acorn
   h. Slotted
   i. Weld
   j. Panel
   k. Serrated
   l. Single thread
   m. Specialty

8. a. Prevailing torque lock nut
   b. Plastic insert lock nut
   c. Jam nut
   d. Castle nut
   e. Slotted nut
   f. Wing nut
   g. Speed nut
   h. Anchor nut
   i. Chamfered nut
   j. Cap nut
   k. Flange-lock nut
   l. Pal nut

9. a,b,c,f

10. a. Flat washer
    b. Lock washer
    c. External toothed lock washer
    d. Internal toothed lock washer
    e. Countersunk external toothed washer

11. b,c

12. c,d

13. a. Cotter pins
    b. Lock wire
    c. Flat metal locks
    d. Lock ears

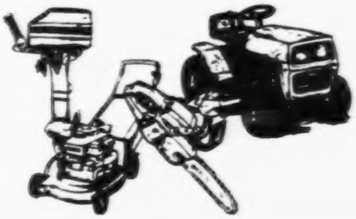
14. a. Round
    b. Fillister
    c. Truss
    d. Pan
    e. Oval

ANSWERS TO TEST

- f. Flat
- g. Cross recessed or phillips
- h. Clutch
- i. Hex slotted

15. a. Internal hole
    b. External "E"
    c. Internal prong
    d. External hole

16. Performance skill evaluated according to standards identified by the instructor



Measuring
Unit IV-A

UNIT OBJECTIVE

After completion of this unit, the student should be able to read and use a plain micrometer, a vernier caliper, and a dial indicator. Competencies will be demonstrated by correctly performing the procedures outlined in the assignment and job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to measuring with their correct definitions.
2. Identify measuring instruments used in small engine repair.
3. Complete a list of steps for reading measuring instruments.
4. Select basic units of measurement found on rules.
5. Identify the major parts of a vernier caliper.
6. Identify the major parts of an outside micrometer.
7. Complete a list of statements concerning proper methods for checking the accuracy of outside micrometers.
8. Identify the major parts of a dial indicator.
9. Arrange in order the steps for set up and use of a dial indicator.
10. Read the plain micrometer settings (Assignment Sheet #1).

OBJECTIVE SHEET

11. Read the vernier micrometer settings (Assignment Sheet #2).

12. Demonstrate the ability to:

    a. Use a vernier caliper (Job Sheet #1).

    b. Use a plain micrometer (Job Sheet #2).

    c. Use a dial indicator (Job Sheet #3).

    d. Use a telescoping gauge (Job Sheet #4).

MEASURING
UNIT IV-A

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with assignment and job sheets prior to the demonstration of the procedures.

H. Integrate the following activities throughout the teaching of this unit:

1. Show examples of measuring tools and discuss their uses.
2. Have students compare prices of measuring tools in various tool catalogs.
3. Obtain software on micrometer reading for use on microcomputer.
4. Discuss procedures outlined in the assignment sheets.
5. Demonstrate and discuss the procedures outlined in the job sheets.
6. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

SUGGESTED ACTIVITIES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

1. TM 1 — Measuring Instruments
2. TM 2 — Measuring Instruments (Continued)
3. TM 3 — Units of Measurement
4. TM 4 — Vernier Caliper Parts
5. TM 5 — Micrometer Parts
6. TM 6 — Checking the Micrometer for Accuracy
7. TM 7 — Dial Indicator Parts
8. TM 8 — Reading a Micrometer
9. TM 9 — Sleeve Readings
10. TM 10 — Overlay A — Thimble Sleeve Readings
11. TM 11 — Vernier Micrometer Readings
12. TM 12 — Overlay B — Vernier Sleeve Readings

E. Assignment sheets

1. Assignment Sheet #1 — Read the Plain Micrometer Settings
2. Assignment Sheet #2 — Read the Vernier Micrometer Settings

F. Answers to assignment sheets

G. Job sheets

1. Job Sheet #1 — Use a Vernier Caliper
2. Job Sheet #2 — Use a Plain Micrometer
3. Job Sheet #3 — Use a Dial Indicator

SUGGESTED ACTIVITIES

4. Job Sheet #4 — Use a Telescoping Gauge

H. Test

I. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

B. Armstrong, Ivan. *Auto Mechanics, Book 1.* Stillwater, Oklahoma: State Department of Vocational-Technical Education, 1976.

MEASURING
UNIT IV-A

INFORMATION SHEET

I. **Terms and definitions**

  A. Steel rule — Low precision measuring instrument graduated in fractional or decimal parts of an inch

  B. Graduation — Marking found on rules and scales to denote unit of length

  C. Error — Mistake in the reading or total measurement

  D. Reliable measure — Accurate or true measurement

  E. Reference point — Starting point of measurement for both workpiece and rule

  F. Vernier caliper — Makes accurate inside and outside measurements to within one-thousandth of an inch, or one-hundredth of a millimeter

II. **Measuring instruments used in small engine repair (Transparencies 1 and 2)**

  A. Rule

  B. Vernier caliper

  C. Micrometers

    1. Inside

    2. Outside

    3. Depth

(NOTE: These can be plain or vernier; plain measures to thousandths of an inch, vernier to ten-thousandths of an inch.)

  D. Dial indicator

  E. Telescoping gauge

  F. Hole gauge

III. **Steps for reading measuring instruments**

  A. Select scale of the required units

  B. Total the number of graduations

  C. Count whole units

  D. Reduce graduations to lowest terms

INFORMATION SHEET

IV. **Basic units of measurement found on rules (Transparency 3)**

A. Fractional

Example: 1/8, 1/16, 1/32

B. Decimal

Example: 0.1, 0.01, 0.001

C. Metric

Example: 1 meter = 1m, 1 millimeter = 1mm

V. **Major parts of vernier caliper (Transparency 4)**

A. Fixed jaw

B. Movable jaw

C. Beam

D. Clamp

E. Clamp screws

F. Main scale

G. Vernier scale

H. Adjusting nut

VI. **Major parts of an outside micrometer (Transparency 5)**

A. Frame

B. Anvil

C. Spindle

D. Lock

E. Sleeve

F. Thimble

G. Ratchet stop

INFORMATION SHEET

VII. **Proper methods for checking accuracy of outside micrometers (Transparency 6)**

A. 0" - 1.000"

1. Close spindle and anvil together
2. Observe zero references on the sleeve and thimble

B. More than one inch

1. Use a standard bar or disc to check the minimum capacity
2. Observe zero references on the sleeve and thimble

VIII. **Major parts of a dial indicator (Transparency 7)**

A. Housing

B. Dial

C. Pointer

D. Plunger

E. Bezel

F. Bezel clamp

IX. **Set up and use of a dial indicator**

A. Secure dial indicator to suitable mounting fixture

B. Position plunger in contact with surface to be measured

C. Pre-load dial indicator

(NOTE: Pre-loading is accomplished by positioning dial indicator so that plunger is depressed equal to two revolutions of the pointer.)

D. Zero dial

(NOTE: To zero dial rotate bezel until zero mark is in line with end of pointer.)

E. Measure work

INFORMATION SHEET

X. **Reading the plain micrometer (Transparencies 8, 9, and 10 [Overlay A])**

A. Each numbered graduation on the sleeve represents one-hundred thousandths of an inch (0.100")

B. Each small graduation on the sleeve between the numbered graduations represents twenty-five thousandths of an inch (0.025")

C. Each graduation found on the thimble represents one thousandth of an inch (0.001")

D. Total reading is found by adding the three values

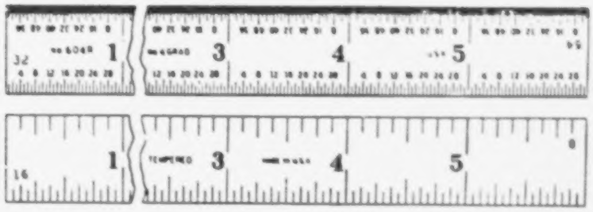
Examples:	0.100	Number on the sleeve
	0.075	Small graduations on the sleeve
	0.015	Graduations on the thimble
	0.190	Plain micrometer reading

XI. **Reading the vernier micrometer (Transparencies 10 [Overlay A], 11, and 12 [Overlay B])**

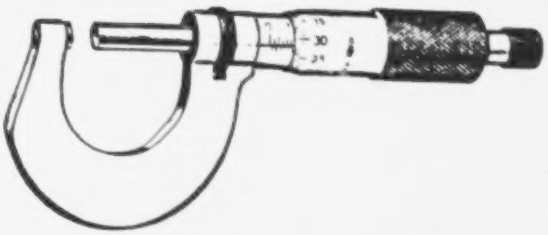
A. Each numbered graduation on the sleeve represents one-hundred thousandths of an inch (0.100")

B. Each small graduation on the sleeve between the numbered graduations represents twenty-five thousandths of an inch (0.025")

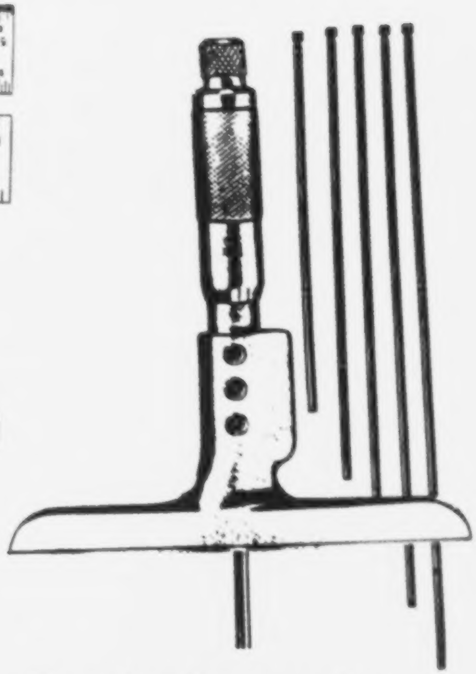
Measuring Instruments



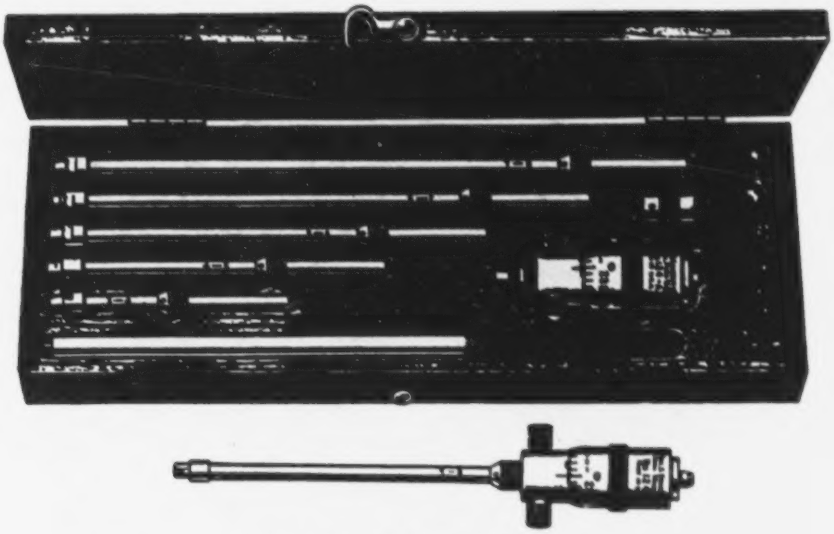
Rules



Outside Micrometer



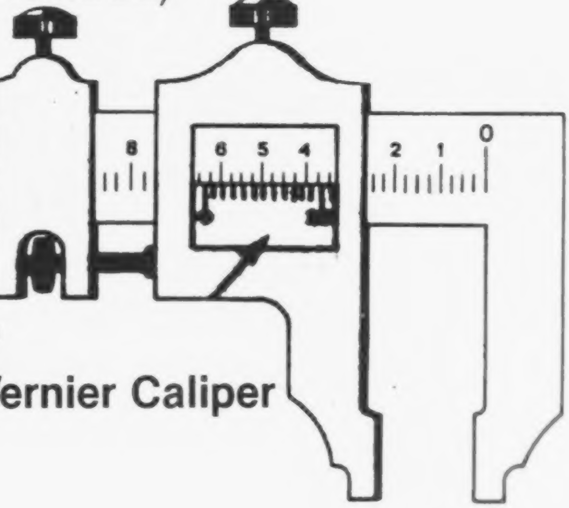
Depth Micrometer



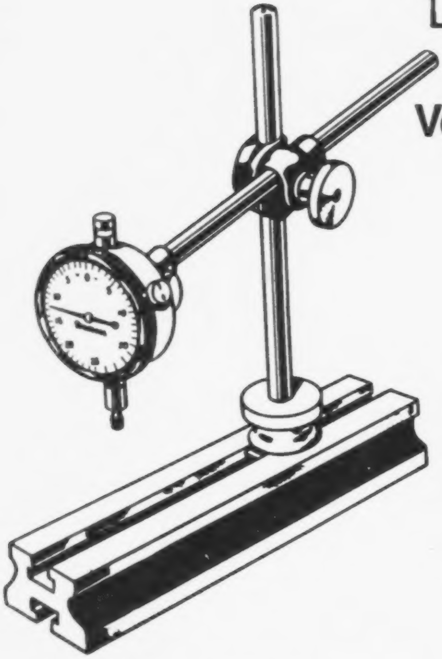
Inside Micrometer

Measuring Instruments

(Continued)


6 5 4 3 2
8
6 5 4
2 1 0

Vernier Caliper

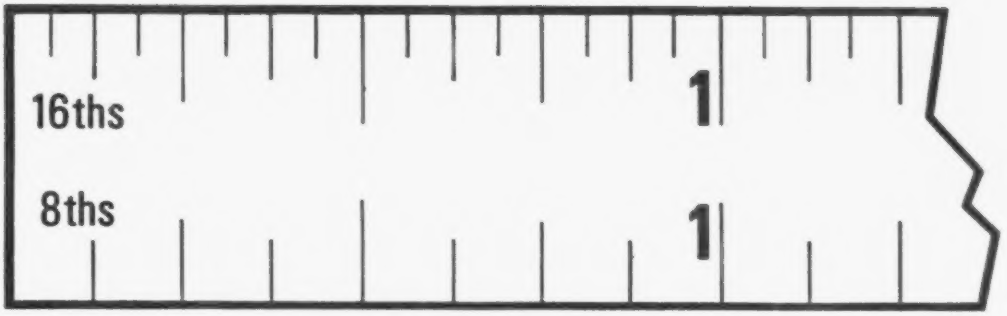


Dial Indicator

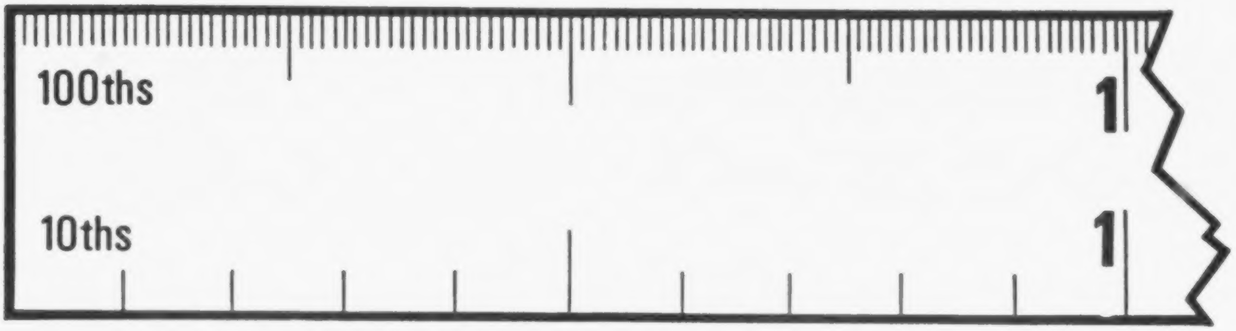
Telescoping Gauge

Hole Gauge

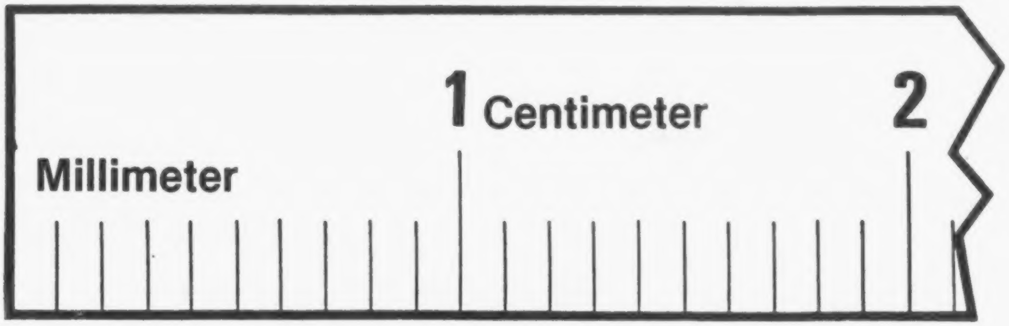
Units of Measurement


16ths
1
8ths
1

Fractional Rule

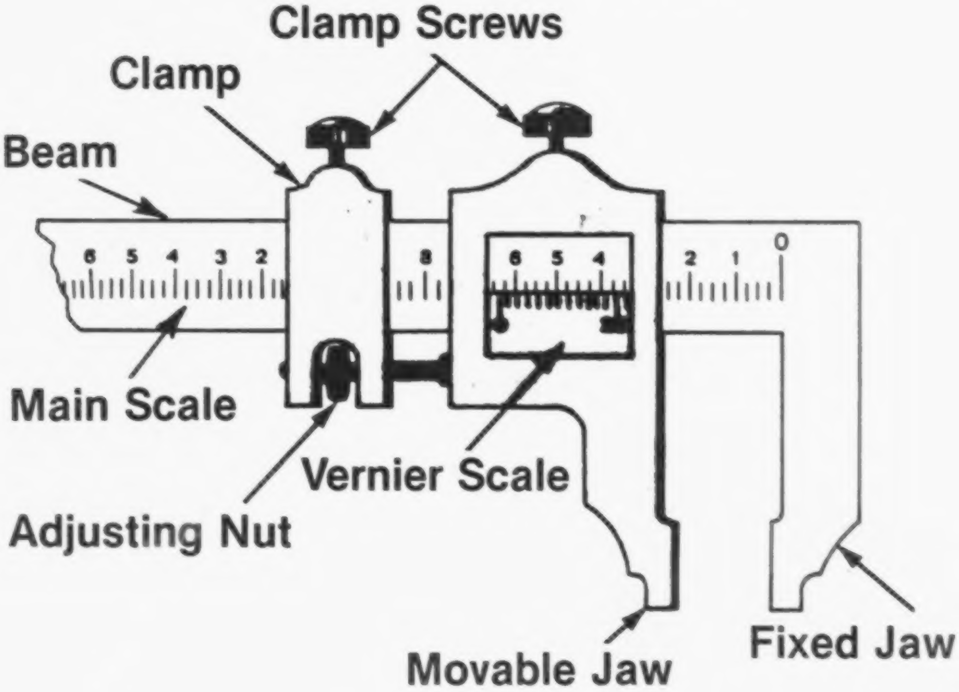

100ths
1
10ths
1

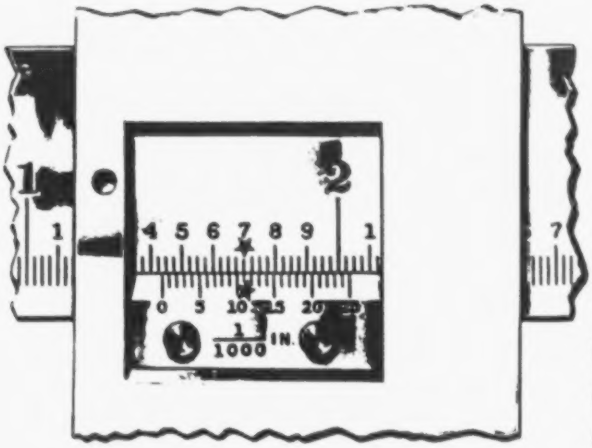
Decimal Rule


1 Centimeter
2
Millimeter

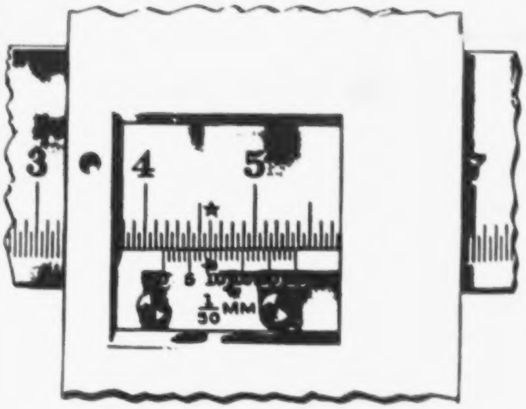
Metric Rule

Vernier Caliper Parts


Clamp Screws
Clamp
Beam
6 5 4 3 2
8
6 5 4
2 1 0
Main Scale
Vernier Scale
Adjusting Nut
Fixed Jaw
Movable Jaw

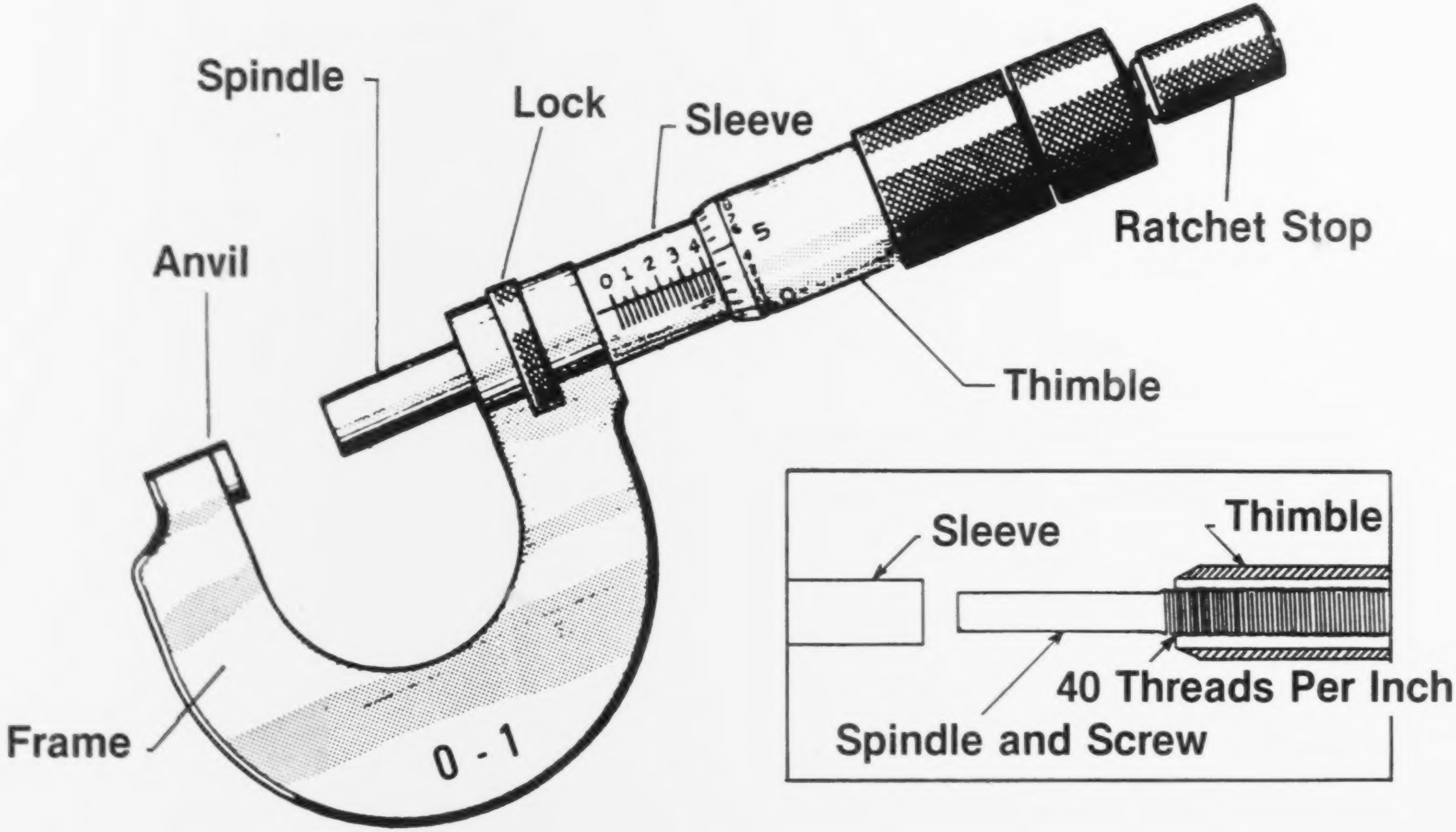

1
2
1
4 5 6 7 8 9
1
7
0 5 10 15 20
1/1000 IN.

Standard Scale

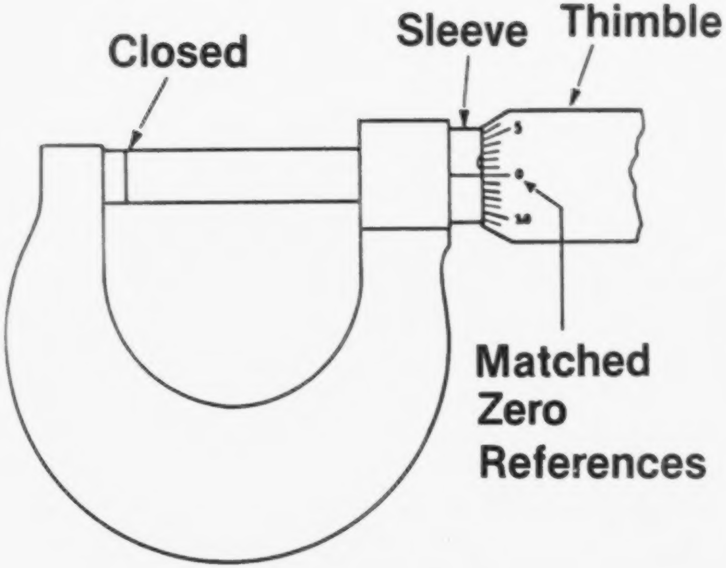


Metric Scale

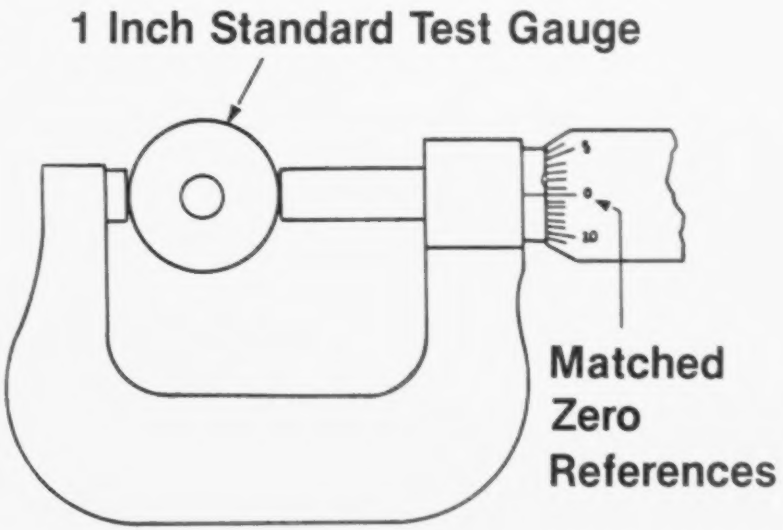
Micrometer Parts


Spindle
Lock
Sleeve
Anvil
Ratchet Stop
Thimble
Frame
0 - 1
0 1 2 3 4
5
0
Sleeve
Thimble
40 Threads Per Inch
Spindle and Screw

Checking the Micrometer for Accuracy

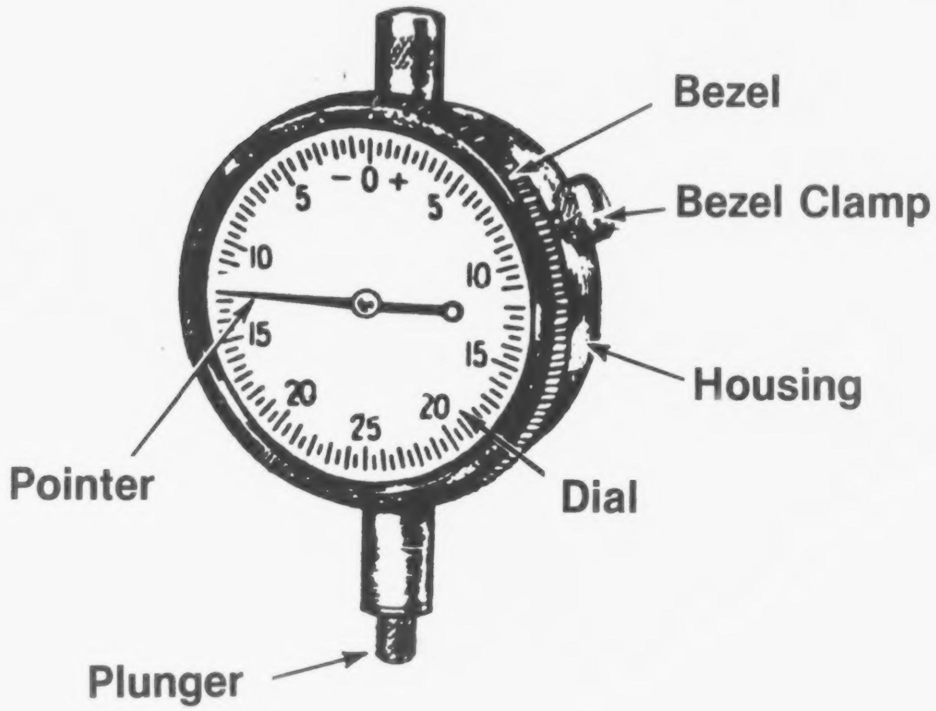

Closed
Sleeve
Thimble
5
0
10
Matched
Zero
References

1 Inch Micrometer

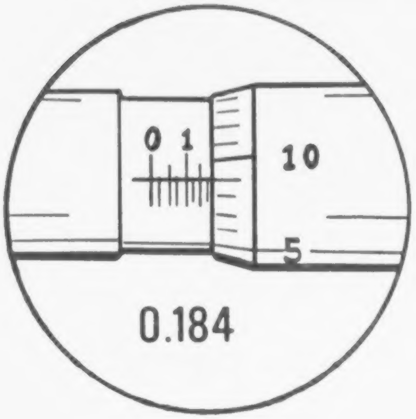

1 Inch Standard Test Gauge
5
0
10
Matched
Zero
References

2 Inch Micrometer

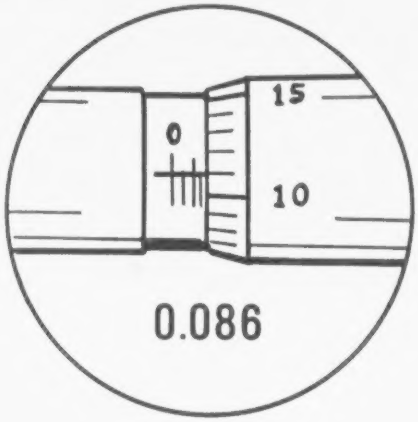
Dial Indicator Parts


Bezel
Bezel Clamp
Housing
Dial
Pointer
Plunger
5
- 0 +
5
10
10
15
15
20
25
20

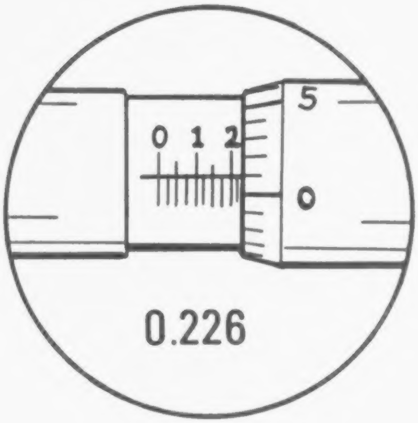
Reading a Micrometer



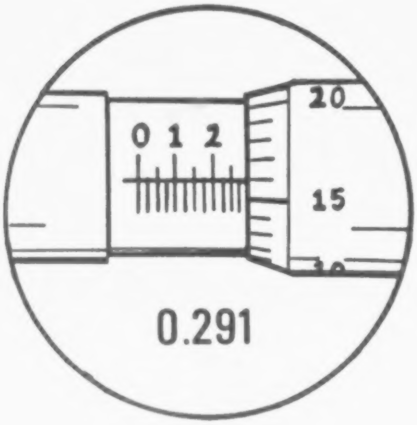
0.184



0.086

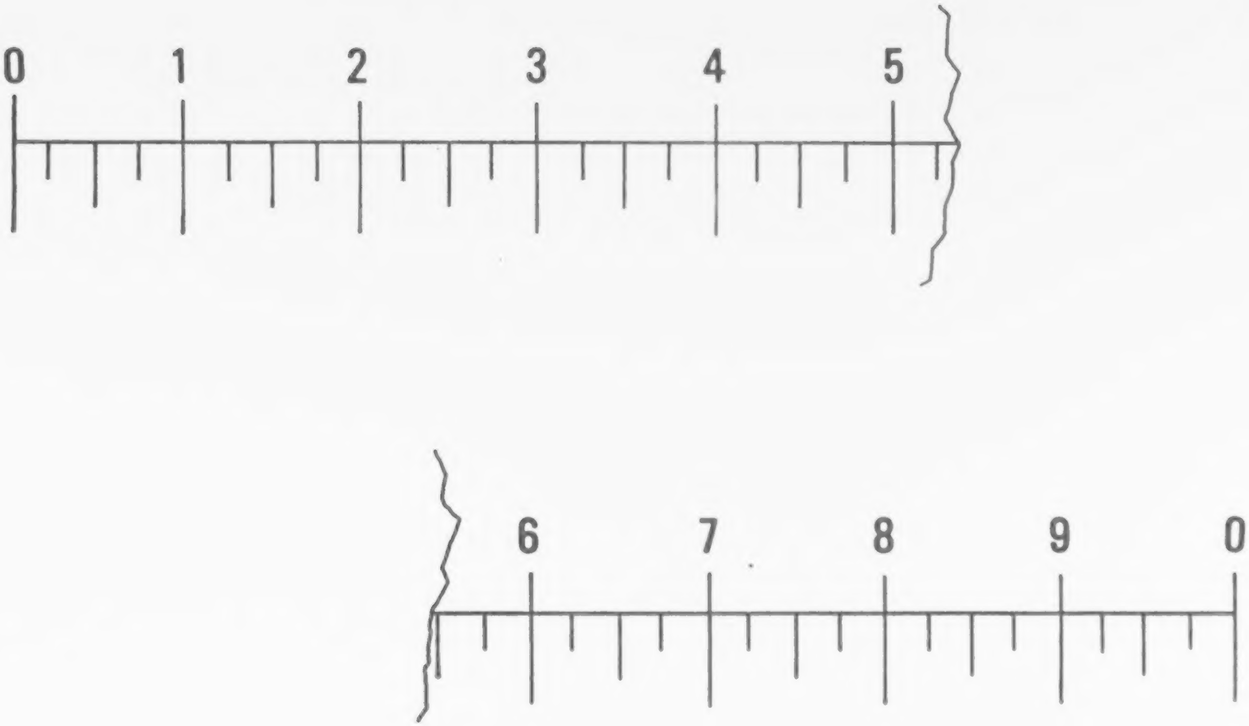


0.226

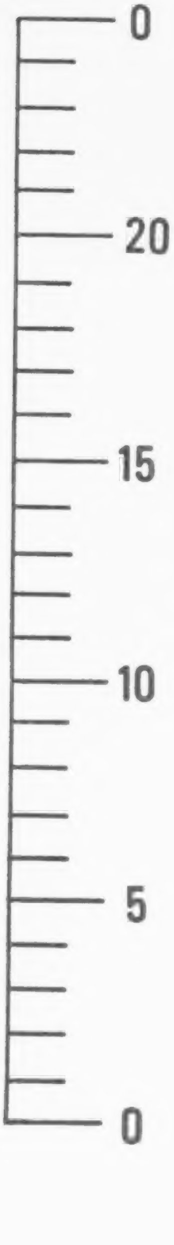


0.291

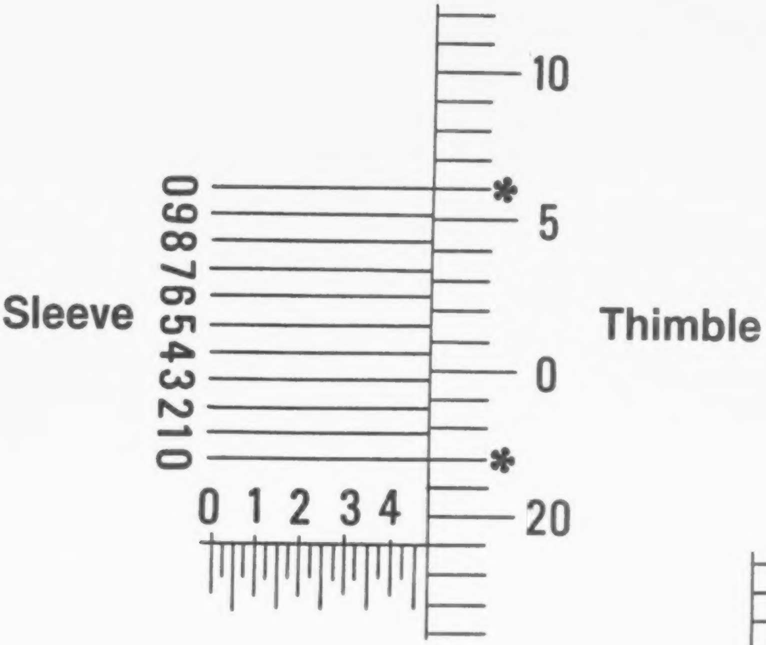
Sleeve Readings


0
1
2
3
4
5
6
7
8
9
0

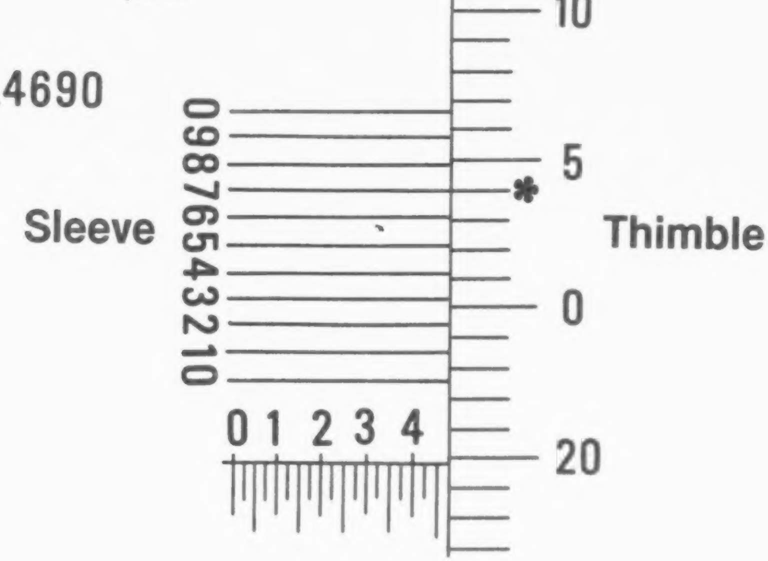
Thimble Sleeve Readings



Vernier Micrometer Readings

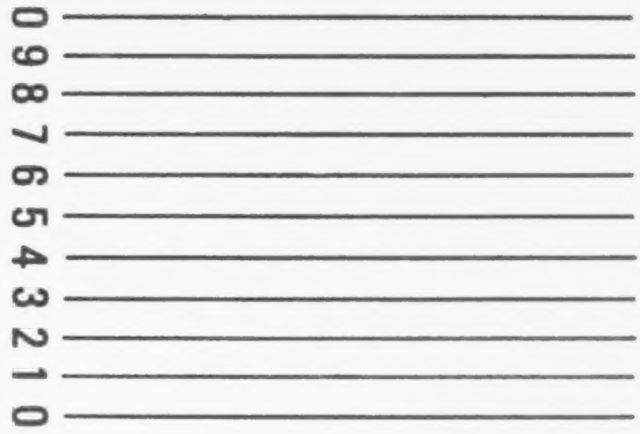

10
*
5
Sleeve
0987654321 0
Thimble
0
*
0 1 2 3 4
20

0.4690


10
5
*
Sleeve
0987654321 0
Thimble
0
0 1 2 3 4
20

0.4697

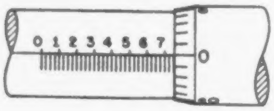
Vernier Sleeve Readings

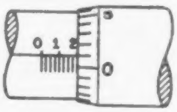

0
9
8
7
6
5
4
3
2
1
0

MEASURING
UNIT IV-A

ASSIGNMENT SHEET #1 — READ THE PLAIN MICROMETER SETTINGS

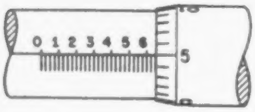
Read the plain micrometer settings below and write the correct answers in the blanks provided.

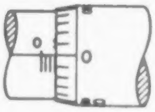




1. ______________________________

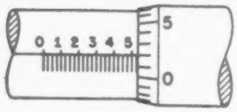
2. ______________________________

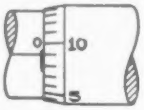




3. ______________________________

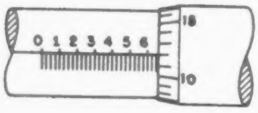
4. ______________________________

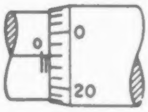




5. ______________________________

6. ______________________________

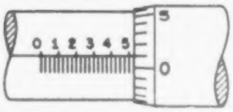

0 1 2 3 4 5 6
15
10



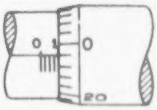
7. ______________________________

8. ______________________________

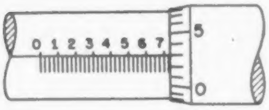
ASSIGNMENT SHEET #1



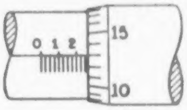
9. ____________________



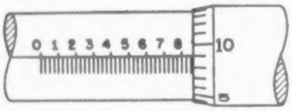
10. ____________________


0 1 2 3 4 5 6 7
5
0

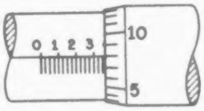
11. ____________________



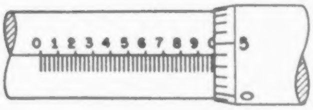
12. ____________________


0 1 2 3 4 5 6 7 8
10
5

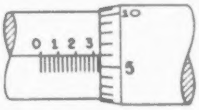
13. ____________________



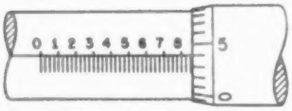
14. ____________________


0 1 2 3 4 5 6 7 8 9 0
5
0

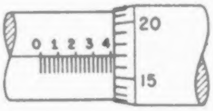
15. ____________________



16. ____________________


0 1 2 3 4 5 6 7 8
5
0

17. ____________________



18. ____________________

MEASURING
UNIT IV-A

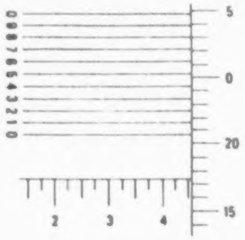
ASSIGNMENT SHEET #2 — READ THE VERNIER MICROMETER SETTINGS

Read the vernier micrometer settings below and write the correct answers in the blanks provided.

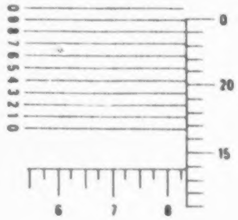
Answers

1. ____________
2. ____________
3. ____________
4. ____________
5. ____________
6. ____________
7. ____________
8. ____________
9. ____________
10. ____________

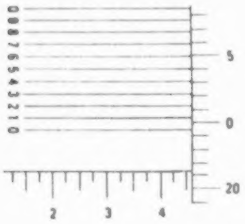
1.


0 9 8 7 6 5 4 3 2 1 0
5
0
20
15
2
3
4

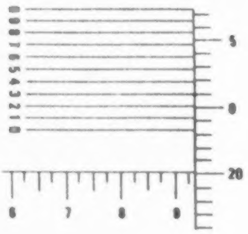
2.


0 9 8 7 6 5 4 3 2 1 0
0
20
15
6
7
8

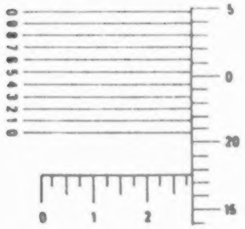
3.


0 9 8 7 6 5 4 3 2 1 0
5
0
20
2
3
4

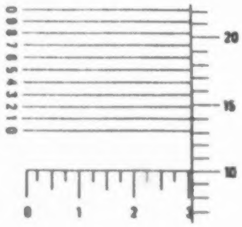
4.


0 9 8 7 6 5 4 3 2 1 0
5
0
20
6
7
8
9

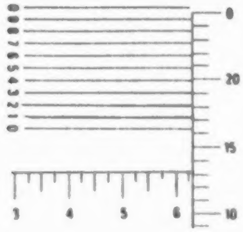
5.


0 9 8 7 6 5 4 3 2 1 0
5
0
20
15
0
1
2

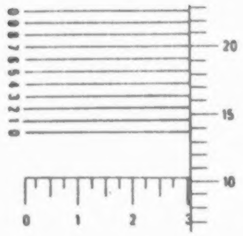
6.


0 9 8 7 6 5 4 3 2 1 0
20
15
10
0
1
2
3

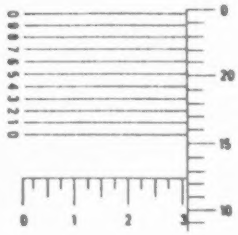
7.


0 9 8 7 6 5 4 3 2 1 0
0
20
15
10
3
4
5
6

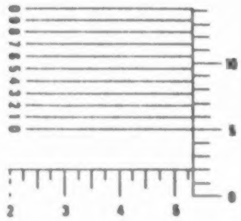
8.


0 9 8 7 6 5 4 3 2 1 0
20
15
10
0
1
2
3

9.


0 9 8 7 6 5 4 3 2 1 0
0
20
15
10
0
1
2
3

10.


0 9 8 7 6 5 4 3 2 1 0
10
5
0
2
3
4
5

MEASURING
UNIT IV-A

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. 0.750
2. 0.201
3. 0.655
4. 0.075
5. 0.527
6. 0.009
7. 0.662
8. 0.048
9. 0.526
10. 0.099
11. 0.728
12. 0.263
13. 0.859
14. 0.358
15. 0.979
16. 0.331
17. 0.854
18. 0.417

Assignment Sheet #2

1. 0.4678
2. 0.8388
3. 0.4715
4. 0.9453
5. 0.2928
6. 0.3101
7. 0.6383
8. 0.3107
9. 0.3128
10. 0.5270

MEASURING
UNIT IV-A

JOB SHEET #1 — USE A VERNIER CALIPER

A. Tools and materials needed

1. Vernier caliper
2. Workpieces
    a. Assortment of fractional drill bits
    b. Assortment of letter size drill bits
    c. Assortment of machined parts

(NOTE: All workpieces should be numbered or lettered for reference.)

B. Procedure

1. Select workpieces that are smooth and free of burrs, nicks, or dents
2. Clean inside faces of caliper jaws
3. Check vernier caliper at zero reference
4. Open caliper greater than thickness of part to be measured
5. Hook end jaw over part to be measured
6. Slide movable jaw into contact with part
7. Tighten clamp screw on fine adjustment nut
8. Make fine adjustment with fine adjusting screw if necessary
9. Tighten clamping screw above vernier plate
10. Remove caliper from work carefully
11. Read caliper
12. List reading according to letter or number on workpiece
13. Return vernier caliper to correct storage place
14. Hand in the listed readings to instructor for evaluation

MEASURING
UNIT IV-A

JOB SHEET #2 — USE A PLAIN MICROMETER

A. Tools and materials needed

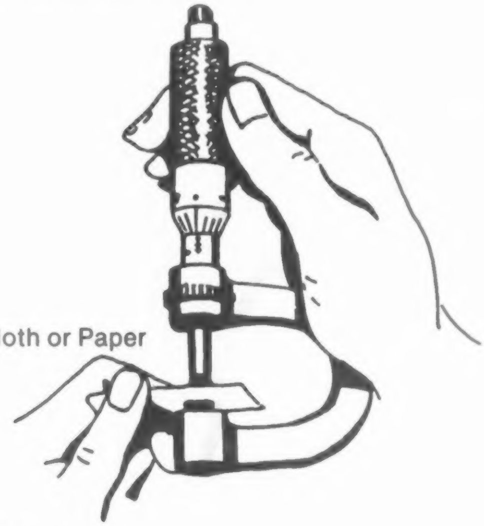
1. Micrometers, plain
    a. 0" - 1.000" size
    b. 1.000" - 2.000" size
2. Lathe or vise
3. Workpieces
    a. New fractional drill bits, assortment of 5
    b. New letter size drill bits, assortment of 5
    c. Pieces of metal such as cold rolled stock, machined parts, hardened dowels; assortment of 5

(NOTE: All workpieces should be numbered or lettered for reference.)

B. Procedure

1. Select workpieces that are clean and free of burrs, nicks, or dents
2. Select the proper size micrometer for the workpiece
3. Clean the spindle and anvil of the micrometer (Figure 1)

FIGURE 1



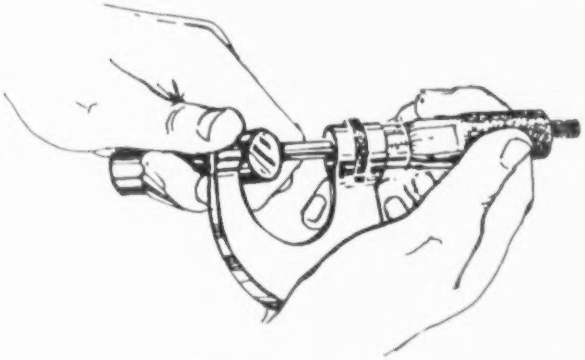
JOB SHEET #2

4. Check the micrometer at zero reference

5. Hold the micrometer according to the type of workpiece

    a. Hold the micrometer in the right hand and the workpiece in the left hand to measure a nonstationary object (Figure 2)

FIGURE 2

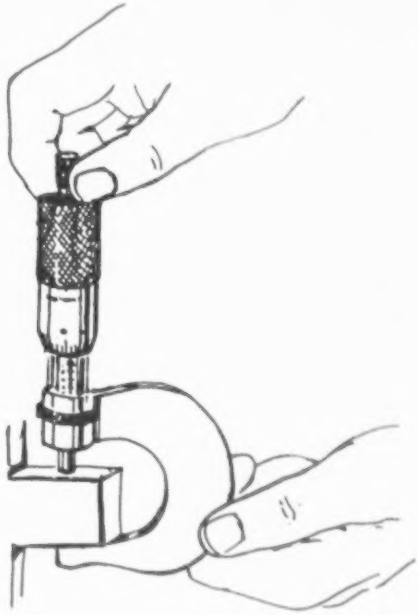


Nonstationary Object

    b. Hold the micrometer in both hands to measure a stationary object (Figure 3)

FIGURE 3

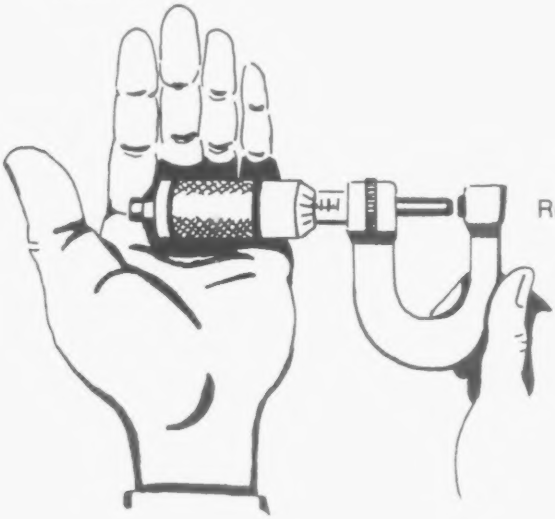
Stationary Object



JOB SHEET #2

(NOTE: Roll micrometer along palm of hand or forearm for quick adjustment. See Figure 4.)

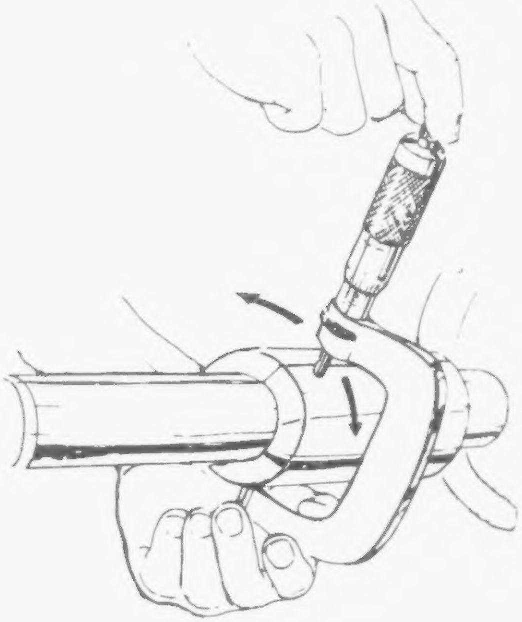
FIGURE 4



Roll For Quick Adjustment

6. Place the micrometer directly over the center of the workpiece to be measured (Figure 5)

FIGURE 5



Work Back and Forth
To Find True Diameter

JOB SHEET #2

7. Turn the thimble of the micrometer until the anvil and spindle contact the workpiece

8. Hold the anvil steady and move the spindle lightly over the workpiece to locate the true centerline

   (NOTE: See Figure 5 on the preceding page.)

9. Use ratchet stop or light sense of feel to determine exact measurement

10. Observe micrometer readings

    (NOTE: Spindle lock can be turned to hold measurement if micrometer must be removed from workpiece. Spindle must be unlocked before resetting to a new measurement.)

11. List the readings according to the letter or number on the workpiece

12. Return the micrometer to its correct storage

    (NOTE: The spindle and anvil of the micrometer should be left open when stored.)

13. Hand in the listed readings to the instructor for evaluation

MEASURING
UNIT IV-A

JOB SHEET #3 — USE A DIAL INDICATOR

A. Tools and materials needed

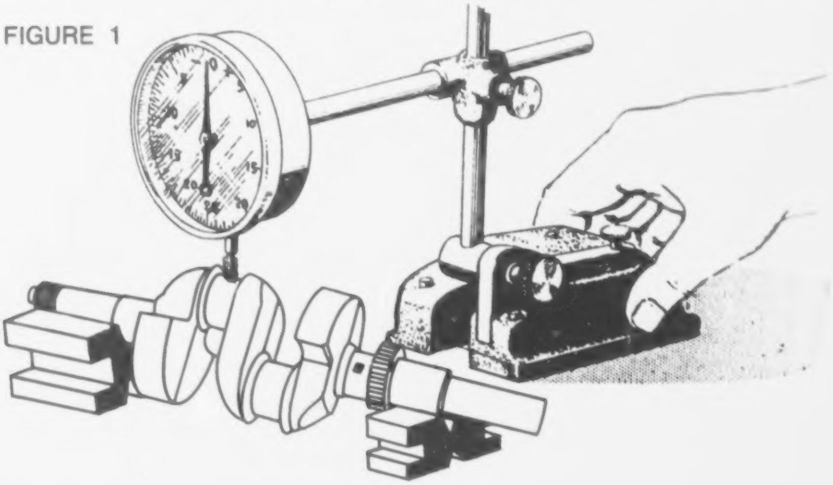
1. Dial indicator
2. Dial indicator holder
3. Magnetic base
4. V blocks - 2
5. Appropriate assortment of machined parts

   (NOTE: All workpieces should be numbered or lettered for reference.)

B. Procedure

1. Select workpieces that are clean and free of burrs, nicks, or dents
2. Attach dial indicator to holder
3. Secure holder to work surface
4. Mount crankshaft according to type of measurement to be made (Figure 1)

FIGURE 1



5. Position holder so that dial indicator plunger contacts workpiece

JOB SHEET #3

6. Adjust holder so that plunger is depressed two revolutions of pointer and tighten holder
7. Rotate bezel until the zero marking is in line with pointer
8. Measure workpiece for taper, concentricity, and run-out
9. List readings according to the letter or number on the workpiece
10. Disassemble dial indicator and holder and return to the correct storage
11. Hand in the listed readings to the instructor for evaluation

MEASURING
UNIT IV-A

JOB SHEET #4 — USE A TELESCOPING GAUGE

A. Tools and materials needed

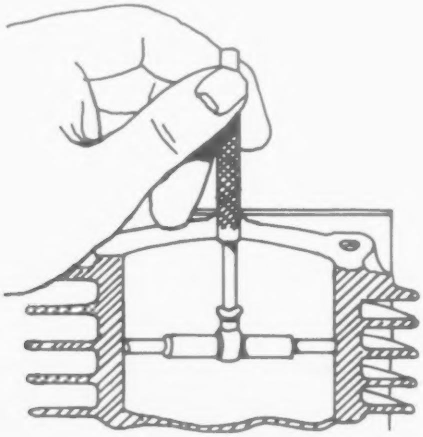
1. Micrometer
2. Telescoping gauge
3. Shop towels
4. Safety glasses

B. Procedure

1. Secure cylinder from instructor to be measured
2. Compress the arms of the telescoping gauge with your hand into a size slightly smaller than the cylinder to be measured and tighten the nut to lock the arms in position
3. Insert the gauge into the cylinder; loosen the nut (Figure 1)

   (NOTE: A light spring inside the arm will push the adjustable end out to fit the cylinder.)

FIGURE 1



JOB SHEET #4

4. Make sure the telescoping end is at right angles to the cylinder wall
5. Tighten the nut and withdraw the gauge
6. Measure the telescoping gauge setting with a micrometer
7. Have your instructor check your work
8. Return tools and materials to their proper places

MEASURING
UNIT IV-A

NAME ____________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. Low precision measuring instrument graduated in fractional or decimal parts of an inch

_____b. Marking found on rules and scales to denote unit of length

_____c. Mistake in the reading or total measurement

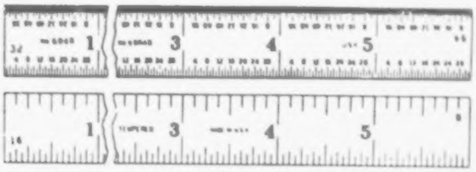
_____d. Accurate or true measurement

_____e. Starting point of measurement for both workpiece and rule

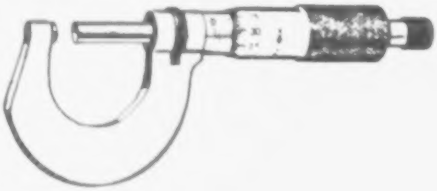
_____f. Makes accurate inside and outside measurements to within one-thousandth of an inch, or one-hundredth of a millimeter

1. Graduation
2. Reliable measure
3. Vernier caliper
4. Steel rule
5. Reference point
6. Error

2. Identify measuring instruments used in small engine repair.

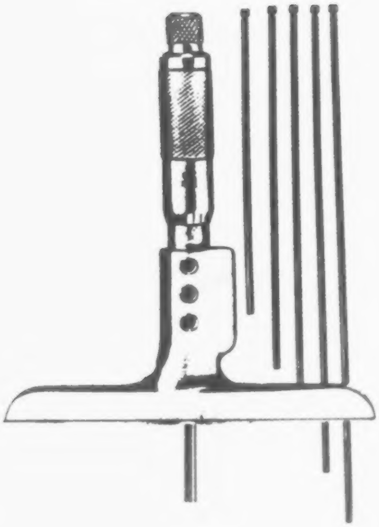


a. ____________________

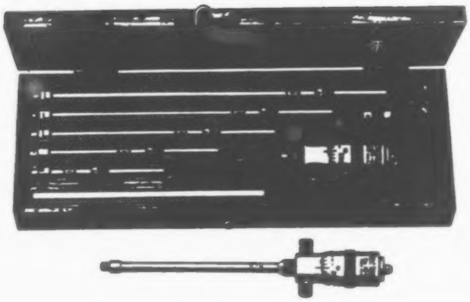


b. ____________________

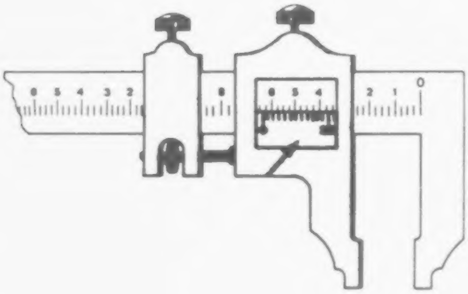
TEST



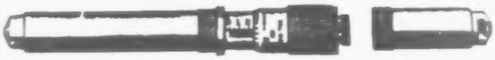
c. ______________________________



d. ______________________________

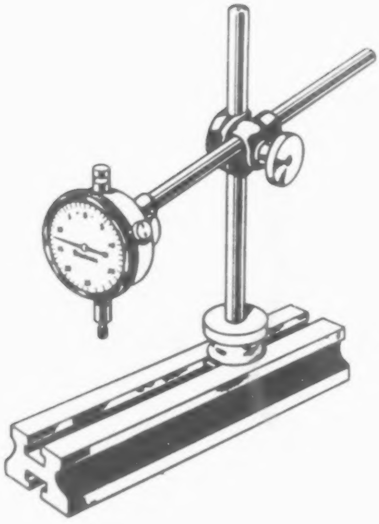


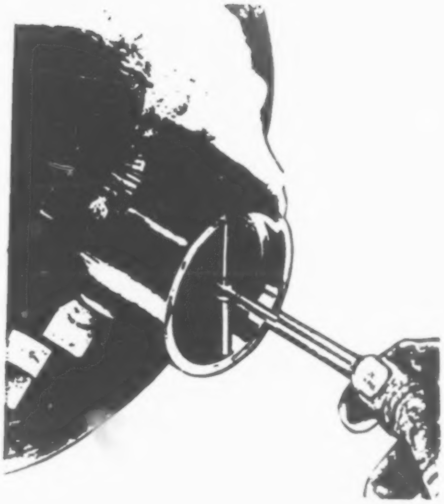
e. ______________________________



f. ______________________________

TEST





g. ______________________________ h. ______________________________

3. Complete the following list of steps for reading measuring instruments by correctly filling in the blanks.

   a. Select ________________ of the required units

   b. Total the number of ________________

   c. Count ________________ units

   d. ________________ graduations to lowest terms

4. Select basic units of measurement found on rules by placing an "X" in the appropriate blanks.

   _____a. Fractional

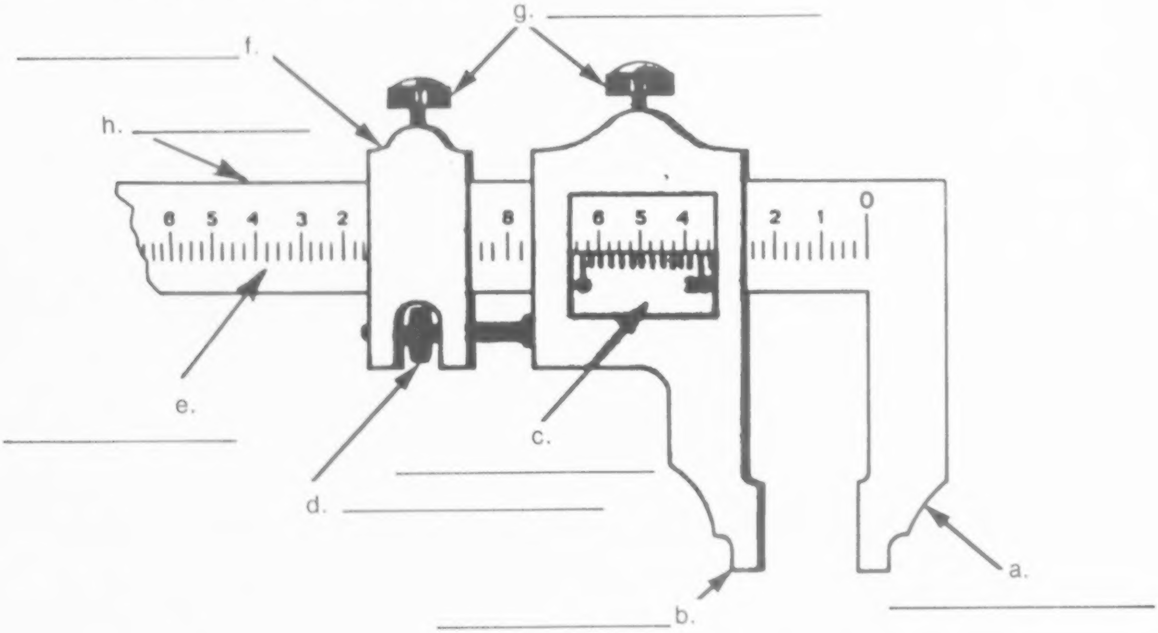
   _____b. Decimal

   _____c. Integral

   _____d. Metric

TEST

5. Identify the major parts of a vernier caliper.



6. Identify the major parts of an outside micrometer.

a. ____________

b. ____________

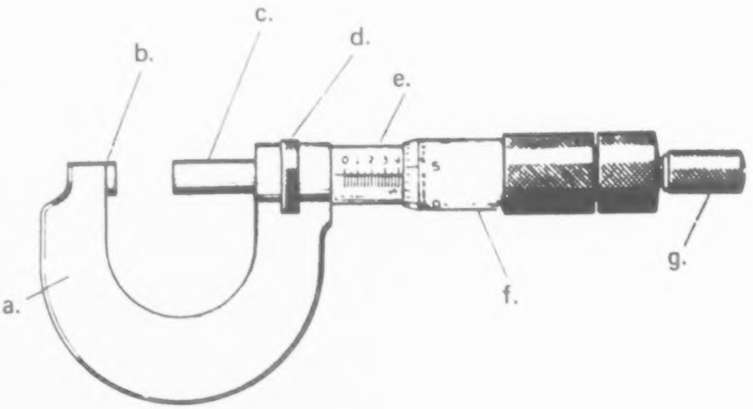
c. ____________

d. ____________

e. ____________

f. ____________

g. ____________



7. Complete the following list of statements concerning methods for checking the accuracy of outside micrometers by correctly filling in the blanks.

a. 0" - 1.000"

1) Close ____________ and anvil together

2) Observe ____________ references on the sleeve and thimble

TEST

b. More than one inch

1) Use a standard bar or disc to check the ________________ capacity

2) Observe zero references on the ________________ and ________________

8. Identify the major parts of a dial indicator.

a. ________________

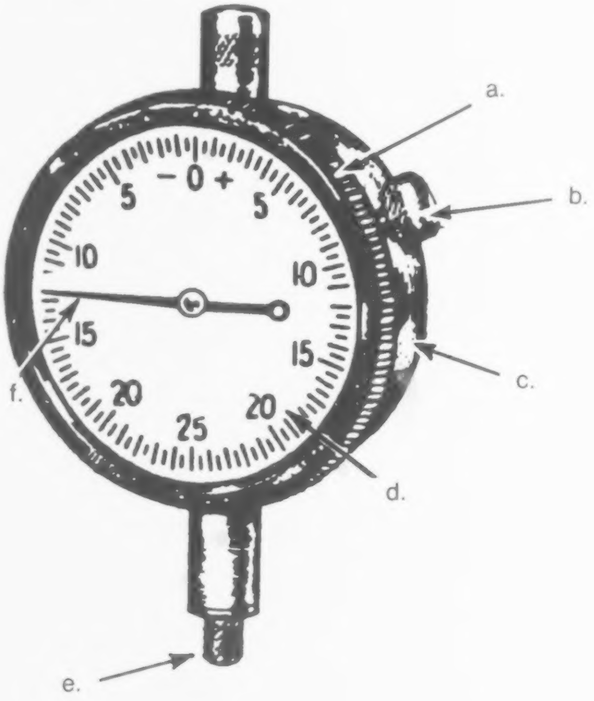
b. ________________

c. ________________

d. ________________

e. ________________

f. ________________



9. Arrange in order the steps for set up and use of a dial indicator by placing the correct sequence numbers in the appropriate blanks.

_____a. Pre-load dial indicator

_____b. Measure work

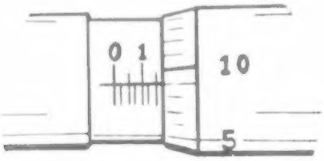
_____c. Position plunger in contact with surface to be measured

_____d. Secure dial indicator to suitable mounting fixture

_____e. Zero dial

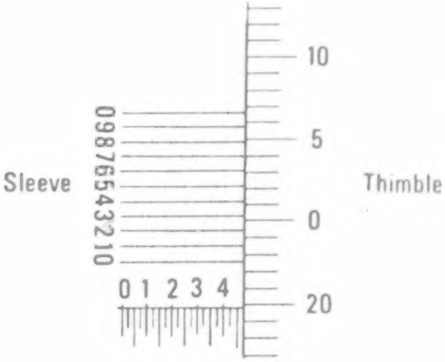
TEST

10. Read the following plain micrometer settings.



Answer: ________________

11. Read the following vernier micrometer settings.


Sleeve
Thimble
0987654321 0
0 1 2 3 4
10
5
0
20

Answer: ________________

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

12. Demonstrate the ability to:

    a. Use a vernier caliper (Job Sheet #1).

    b. Use a plain micrometer (Job Sheet #2).

    c. Use a dial indicator (Job Sheet #3).

    d. Use a telescoping gauge (Job Sheet #4).

MEASURING
UNIT IV-A

ANSWERS TO TEST

1. a. 4
   b. 1
   c. 6
   d. 2
   e. 5
   f. 3

2. a. Rule
   b. Outside micrometer
   c. Depth micrometer
   d. Inside micrometer
   e. Vernier caliper
   f. Hole gauge
   g. Dial indicator
   h. Telescoping gauge

3. a. Scale
   b. Graduations
   c. Whole
   d. Reduce

4. a,b,d

5. a. Fixed jaw
   b. Movable jaw
   c. Vernier scale
   d. Adjusting nut
   e. Main scale
   f. Clamp
   g. Clamp screws
   h. Beam

6. a. Frame
   b. Anvil
   c. Spindle
   d. Lock
   e. Sleeve
   f. Thimble
   g. Ratchet stop

7. a. 0" - 1.000"
      1) Spindle
      2) Zero

   b. More than one inch
      1) Minimum
      2) Sleeve, thimble

ANSWERS TO TEST

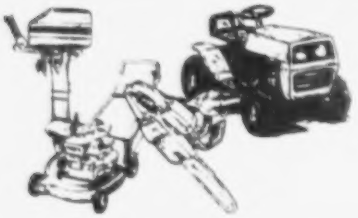
8. a. Bezel
   b. Clamp
   c. Housing
   d. Dial
   e. Plunger
   f. Pointer

9. a. 3
   b. 5
   c. 2
   d. 1
   e. 4

10. 0.159

11. 0.4697

12. Performance skills evaluated according to the standards identified by the instrucfor.



Engine Identification & Inspection
Unit I-B

UNIT OBJECTIVE

After completion of this unit, the student should be able to distinguish between characteristics of a four-cycle and a two-cycle engine and complete engine information forms. Competencies will be demonstrated by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to engine identification and inspection with their correct definitions.
2. Distinguish between the characteristics of a four-stroke cycle engine and a two-stroke cycle engine.
3. Select true statements concerning the meaning of the model, type and code numbers found on the engine.
4. Select engine information which may be determined from the operator's instructions and/or inspection of the engine.
5. Identify the operating positions of the crankshaft.
6. Complete an engine information form (Assignment Sheet #1).
7. Complete an information form on accessories and major units found on an engine (Assignment Sheet #2 — Optional).

ENGINE IDENTIFICATION AND INSPECTION
UNIT I-B

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with assignment sheets.

H. Integrate the following activities throughout the teaching of this unit:

1. Discuss decoding of serial numbers with students.
2. Show examples of different types of engines and demonstrate their differences.
3. Provide students with information on locating the nameplate and finding information about engine.
4. Have operator's instruction booklets for engines available for use by the class.
5. Show students how to complete a work order and have them practice procedure.
6. Show examples of different operating positions of the crankshaft.
7. Discuss procedures outlined in assignment sheets.

   (NOTE: Assignment Sheet #2 is optional and may be used to provide additional experience for advanced students.)

SUGGESTED ACTIVITIES

  8. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

  1. TM 1 — Engine Type Identification

  2. TM 2 — Nameplate Information

  3. TM 3 — Operating Positions of Crankshafts

E. Assignment sheets

  1. Assignment Sheet #1 — Complete an Engine Information Form

  2. Assignment Sheet #2 — Complete an Information Form on Accessories and Major Units Found on an Engine (Optional)

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Small Engines.* Volume 1. Athens, Georgia: American Association for Vocational Instructional Materials.

B. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

ENGINE IDENTIFICATION AND INSPECTION
UNIT I-B

INFORMATION SHEET

I. **Terms and definitions**

   A. Combustion chamber — Area between the piston and cylinder head when the piston is at the top of its stroke

      (NOTE: It is in this area where the compressed fuel mixture is ignited and burned.)

   B. Crankcase — Housing for the crankshaft and other related internal parts

   C. Cycle — Completion of a series of events to produce a power impulse

   D. Exhaust port — Opening to the outside of the combustion chamber for the release of exhaust gases

   E. Intake port — Opening into the combustion chamber for the intake of the fuel-air charge

      (NOTE: This is also called the transfer port on some engines.)

   F. Four-stroke cycle engine — Engine design which develops a power stroke every other revolution of the crankshaft

   G. Two-stroke cycle engine — Engine design permitting a power stroke once for each revolution of the crankshaft

   H. Nameplate — Information plate attached by the manufacturer giving their name, the engine make, model, serial number, and other information

II. **Characteristics of four-stroke cycle and two-stroke cycle engines (Transparency 1)**

   A. Four-stroke cycle engine

      1. Usually has an oil sump and possibly an oil filter

      2. Exhaust muffler connects at the head of the engine cylinder

      3. Carburetor will always be on or near the cylinder head

      4. Compression resistance is felt every other revolution

INFORMATION SHEET

B. Two-stroke cycle engine

1. Does not have an oil sump and oil filter
2. Exhaust port is about midpoint on the cylinder
3. Carburetor may be located at the base of the cylinder or on the bottom or side of the crankcase
4. Compression resistance is felt every revolution

III. **Meaning of the model, type and code numbers found on the engine (Transparencies 1 and 2)**

(NOTE: These numbers are essential to order parts. This information will be found stamped on the blower housing of most engines, or a special metal tag. The following information is for Briggs and Stratton Engines.)

A. Model numbers describe the basic engine

(NOTE: For example, the model #92902. Read numbers in sequence. The "9" indicates the piston displacement is 9 cubic inches. The "2" indicates the basic design series, in this case indicating the engine has a aluminum bore with a chrome plated piston. "9" means the crankshaft position is vertical and the engine is equipped with a Pulsa-Jet carburetor and has an air vane governor. The next "0" indicates the engine has plain bearings, and the "2" indicates the engine has a rewind type starter.)

B. The type number describes the variations of the engine and these numbers are required when ordering parts

(NOTE: For example, the type number 0515-01. The first four digits indicate the mechanical parts of the engine. The following two digits describe the trim, color of paint and packaging for the engine.)

C. The code number indicates the date the engine was built and assembly line number making the engine

(NOTE: For example, the 8408041 indicates the engine was built 1984 — eight month — fourth day on assembly line No. 1.)

	In sequence
84	indicates year of engine
08	indicates month
04	indicates day
1	indicates assembly line

INFORMATION SHEET

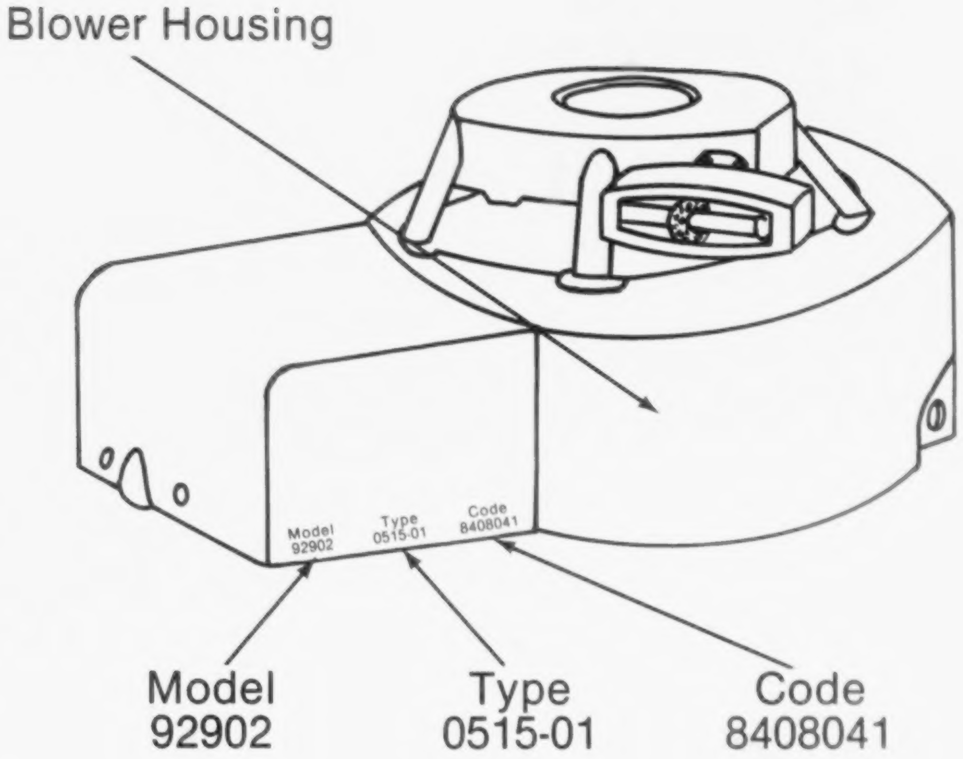
IV. **Engine information which may be determined from the operator's instructions and/or inspection of the engine**

- A. General information
  - 1. Name of equipment manufacturer
  - 2. Address of equipment manufacturer
- B. Operating position of the crankshaft (Transparency 3)
- C. Engine cycle
- D. Model and other numbers
- E. Types of accessories and major units
- F. Service and maintenance specifications

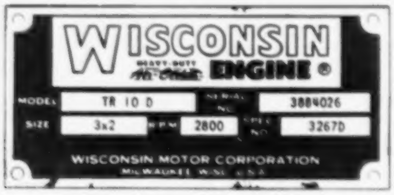
V. **Operating positions of the crankshaft (Transparency 3)**

- A. Vertical
- B. Horizontal
- C. Multi-position

Engine Type Identification


Blower Housing
Model 92902
Type 0515-01
Code 8408041
Model
92902
Type
0515-01
Code
8408041

Nameplate Information

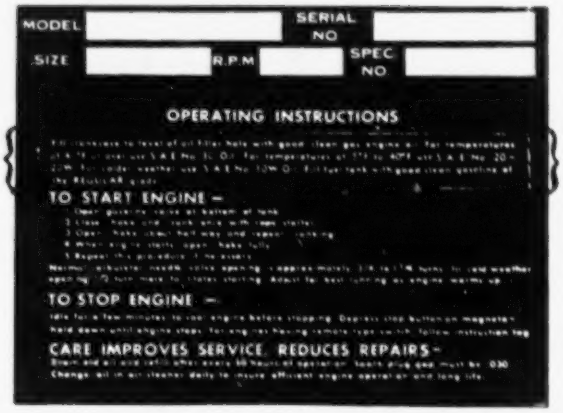


WISCONSIN
HEAVY-DUTY AIR COOLED ENGINE ®

MODEL	TR 10 D		SERIAL NO	3884026	
SIZE	3x2	R.P.M	2800	SPEC NO	3267D

WISCONSIN MOTOR CORPORATION
MILWAUKEE WISC U.S.A.

Nameplate



MODEL			SERIAL NO		
SIZE		R.P.M		SPEC NO	

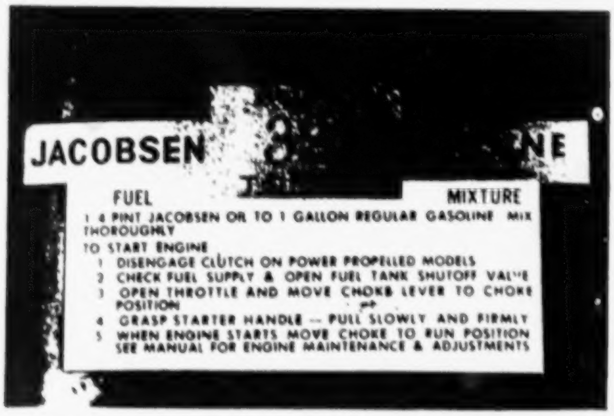
OPERATING INSTRUCTIONS

TO START ENGINE —

TO STOP ENGINE —

CARE IMPROVES SERVICE, REDUCES REPAIRS—

Four-Stroke Cycle Engine



JACOBSEN

NE

FUEL MIXTURE

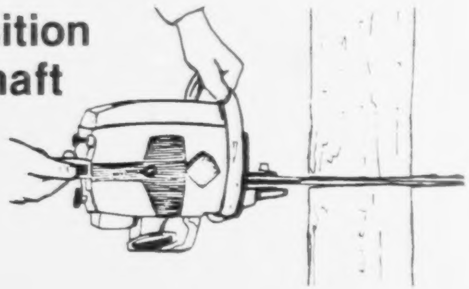
1 4 PINT JACOBSEN OIL TO 1 GALLON REGULAR GASOLINE MIX THOROUGHLY

TO START ENGINE
1 DISENGAGE CLUTCH ON POWER PROPELLED MODELS
2 CHECK FUEL SUPPLY & OPEN FUEL TANK SHUTOFF VALVE
3 OPEN THROTTLE AND MOVE CHOKE LEVER TO CHOKE POSITION
4 GRASP STARTER HANDLE — PULL SLOWLY AND FIRMLY
5 WHEN ENGINE STARTS MOVE CHOKE TO RUN POSITION
SEE MANUAL FOR ENGINE MAINTENANCE & ADJUSTMENTS

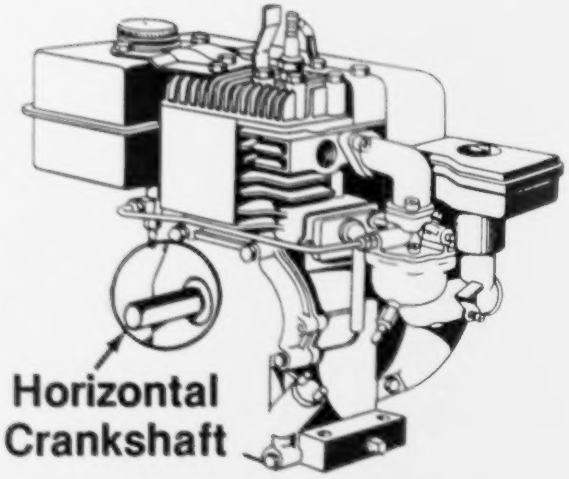
Two-Stroke Cycle Engine

BEST COPY AVAILABLE

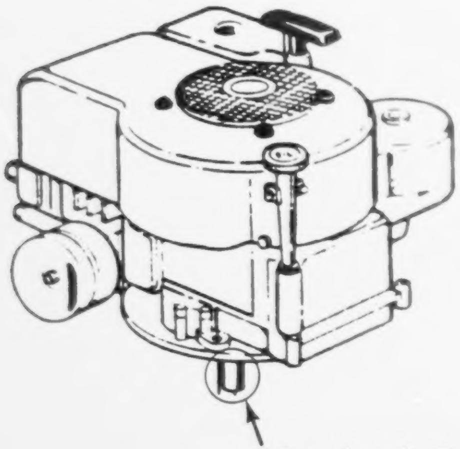
Operating Positions of Crankshafts



Multi-Position Crankshaft



Horizontal Crankshaft



Vertical Crankshaft

ENGINE IDENTIFICATION AND INSPECTION
UNIT I-B

ASSIGNMENT SHEET #1 — COMPLETE AN ENGINE INFORMATION FORM

Complete the following engine information form by looking at an engine and its operator's manual.

NAME OF EQUIPMENT (ON WHICH ENGINE IS MOUNTED) ______________________________

NAME AND ADDRESS OF EQUIPMENT MANUFACTURER ______________________________

____

NAME AND ADDRESS OF ENGINE MANUFACTURER ______________________________

____

OPERATING POSITION OF CRANKSHAFT: VERTICAL _____, HORIZONTAL _____, MULTI-POSITION _____.

ENGINE CYCLE: 2-Cycle _____, 4-Cycle _____.

MODEL NUMBER ____

SERIAL NUMBER ____

SPECIFICATION NUMBER ____

TYPE NUMBER ____

HORSEPOWER ____

ADDITIONAL INFORMATION ____

____

____

____

ENGINE IDENTIFICATION AND INSPECTION
UNIT I-B

ASSIGNMENT SHEET #2 — COMPLETE AN ENGINE INFORMATION FORM ON ACCESSORIES AND MAJOR UNITS FOUND ON AN ENGINE

(NOTE: This is an optional assignment sheet and you may wish to complete the following form after studying additional units in this manual. Check with your instructor.)

Types of accessories and major units:

Carburetor air cleaner: Oil bath ____, Oiled filter ____, Dry filter ____.

Fuel strainer: Combination screen and sediment bowl ____, Screen inside the fuel tank ____.

Crankcase breather: Reed valve ____, Floating disc valve ____.

Starter: Rope-wind ____, Rope-rewind ____, Wind up ____, Electric, AC ____, Electric, DC ____.

Ignition system: Flywheel magneto ____, External magnet ____, Battery ____.

Fuel pump: ____

Carburetor: Float ____, Suction lift ____, Diaphragm ____.

Governor: Air vane ____, Centrifugal ____.

Service and maintenance specifications:

Fuel: Mixture of oil and gasoline (2-cycle) Refer to Operator's Manual for the correct fuel mixture specific to your equipment.

____

Oil: SAE grade: 5 W ____, SAE 10 W ____, SAE 20 W ____, SAE 30 ____, SAE 10 W-30 ____.
Classification: ____SC ____SD ____SE ____SF

Type of spark plug: ____ Gap setting .020", .025", Other ____

Ignition breaker-point gap: .012" ____, .015" ____, Other ____

ENGINE IDENTIFICATION AND INSPECTION
UNIT I-B

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

______a. Area between the piston and cylinder head when the piston is at the top of its stroke

______b. Information plate attached by the manufacturer giving their name, the engine make, model, serial number, and other information

______c. Opening into the combustion chamber for the intake of the fuel-air charge

______d. Engine design which develops a power stroke every other revolution of the crankshaft

______e. Completion of a series of events to produce a power impulse

______f. Opening to the outside of the combustion chamber for the release of exhaust gases

______g. Engine design permitting a power stroke once for each revolution of the crankshaft

______h. Housing for the crankshaft and other related internal parts

1. Nameplate
2. Exhaust port
3. Combustion chamber
4. Crankcase
5. Two-stroke cycle engine
6. Intake port
7. Four-stroke cycle engine
8. Cycle

2. Distinguish between the characteristics of a four-stroke cycle engine and a two-stroke cycle engine by placing an "X" next to the characteristics of a four-stroke cycle engine.

______a. Carburetor will always be on or near the cylinder head

______b. Usually has an oil sump and possibly an oil filter

______c. Compression resistance is felt every other revolution

______d. Exhaust port is about midpoint on the cylinder

______e. Compression resistance is felt every revolution

______f. Does not have an oil sump and oil filter

______g. Carburetor will always be on or near the cylinder head

TEST

3. Select true statements concerning the meaning of the model, type and code numbers found on the engine by placing an "X" in the appropriate blanks.

_____a. Model numbers describe the variations of the engine and these numbers are required when ordering parts

_____b. The type number describes the variations of the engine and these numbers are required when ordering parts

_____c. The code number indicates the date the engine was built and assembly line number making the engine

_____d. Model numbers describe the basic engine

_____e. The code number describes the basic engine

4. Select engine information which may be determined from the operator's instructions and/or inspection of the engine by placing an "X" in the appropriate blanks.

_____a. Engine cycle

_____b. Model and other numbers

_____c. Service and maintenance specifications

_____d. Paint specifications on engine block

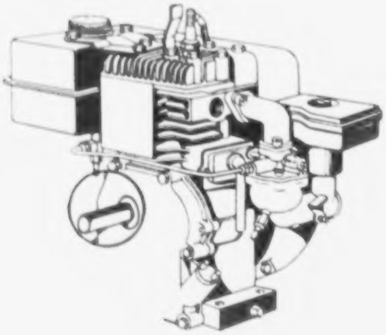
_____e. Diameter of wire on high tension leads

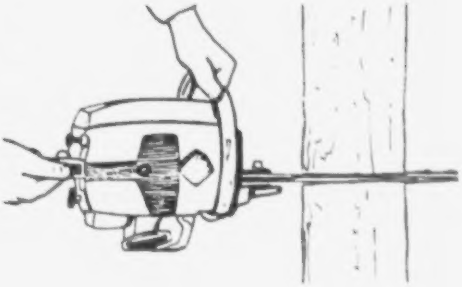
_____f. Operating position of the crankshaft

_____g. Breaker point weight

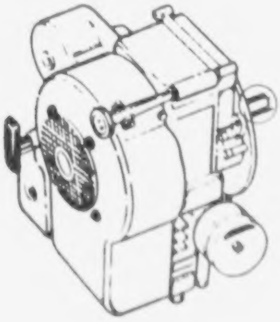
TEST

5. Identify the operating positions of the following crankshafts.





a. ______________________ b. ______________________



c. ______________________

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

6. Complete an engine information form (Assignment Sheet #1).

7. Complete an information form on accessories and major units found on an engine (Assignment Sheet #2 — Optional).

ENGINE IDENTIFICATION AND INSPECTION
UNIT I-B

ANSWERS TO TEST

1. a. 3
   b. 1
   c. 6
   d. 7
   e. 8
   f. 2
   g. 5
   h. 4

2. a,b,c,g

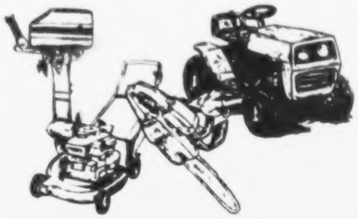
3. b,c,d

4. a,b,c,f

5. a. Horizontal
   b. Multi-position
   c. Vertical

6. Evaluated according to standards identified by the instructor

7. Evaluated according to standards identified by the instructor



Basic Engine Principles & Design
Unit II-B

UNIT OBJECTIVE

After completion of this unit, the student should be able to calculate problems dealing with work, horsepower, torque, and cubic inch displacement. Competencies will be demonstrated by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to basic engine principles with their correct definitions.
2. List three characteristics of energy.
3. Select types of energy.
4. List two forms of available energy.
5. Select types of motion.
6. Calculate problems using the formula for work (Assignment Sheet #1).
7. Calculate problems using the formula for horsepower (Assignment Sheet #2).
8. Calculate problems using the formula for torque (Assignment Sheet #3).
9. Match the parts of a basic internal combustion engine with their correct descriptions.
10. Complete a list of statements concerning the process by which an internal combustion engine converts chemical energy into rotary motion.

OBJECTIVE SHEET

11. Calculate problems using the formula for engine cubic inch displacement (Assignment Sheet #4).

12. Calculate problems using the formula for compression ratio (Assignment Sheet #5).

13. Identify types of engine design.

14. Identify types of engine cooling.

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II-B

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with assignment sheets.

H. Integrate the following activities throughout the teaching of this unit:

1. Check with the major small engine manufacturers for visual aids to demonstrate basic engine principles.
2. Give examples of types of motion. If possible, show examples to class.
3. Discuss procedures outlined in assignment sheets.
4. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

SUGGESTED ACTIVITIES

D. Transparency masters

1. TM 1 — Types of Motion
2. TM 2 — Basic Internal Combustion Engine Parts
3. TM 3 — Chemical Energy to Rotary Motion
4. TM 4 — Cubic Inch Displacement
5. TM 5 — Compression Ratio-6 to 1
6. TM 6 — Engine Designs
7. TM 7 — Engine Designs (Continued)
8. TM 8 — Engine Cooling Systems

E. Assignment sheets

1. Assignment Sheet #1 — Calculate Work
2. Assignment Sheet #2 — Calculate Horsepower
3. Assignment Sheet #3 — Calculate Torque
4. Assignment Sheet #4 — Calculate Cubic Inch Displacement
5. Assignment Sheet #5 — Calculate Compression Ratio

F. Answers to assignment sheets

G. Test

H. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Bohn, Ralph C., and MacDonald, Angus J. *Power: Mechanics of Energy Control.* Bloomington, Illinois: McKnight and McKnight, 1970.

B. Stockel, Martin W. *Auto Mechanics Fundamentals.* South Holland, Illinois: Goodheart-Willcox Co., 1982.

C. *A Power Primer.* Detroit, Michigan: General Motors.

D. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II-B

INFORMATION SHEET

I. **Terms and definitions**

A. Force — Any agent that produces or tends to produce motion

B. Work — Results of force overcoming a resistance over a definite distance

C. Energy — Ability to do work

D. Potential energy — Stored energy

E. Kinetic energy — Energy in motion

F. Power — Rate at which work is done

G. Horsepower — Measurement of work accomplished in a given period of time

(NOTE: One horsepower is a unit of power equal to 746 watts.)

H. Torque — Measurement of turning effort

I. Friction — Resistance to relative motion between two bodies in contact

J. PSI — Pounds per square inch; most common unit for measuring pressure

(NOTE: The metric equivalent to psi is kilogram per square centimeter, kg/cm^2.)

K. Mechanical power — Transmission and control of motion through the use of gears, pulleys, shafts, and other mechanical devices

L. Reciprocating motion — Back and forth motion

M. Cycle — Series of events or operations that happen regularly and lead back to the starting point

N. Control — To exercise restraining or directing influence over working forces

O. Transmission — Relaying of a working force

P. TDC — Top dead center

(NOTE: TDC may also be stated as ATDC, after top dead center, or BTDC, before top dead center.)

INFORMATION SHEET

Q. BDC — Bottom dead center

(NOTE: BDC may also be stated as ABDC, after bottom dead center, or BBDC, before bottom dead center.)

R. Stroke — Distance the piston moves when traveling from TDC to BDC

S. Bore — Diameter of the cylinder

T. Displacement — Total volume of air-fuel compressed by the piston in traveling from BDC to TDC

U. CID — Cubic inch displacement

(NOTE: Metric measurement for displacement is in cubic centimeters or liters.)

V. Combustion — Action or operation of burning

II. **Characteristics of energy**

A. Energy is ever present

B. Energy cannot be created or destroyed

C. Energy can only be changed from one kind to another

III. **Types of energy**

A. Light

(NOTE: Light energy promotes growth in plants and makes our surroundings visible.)

B. Heat

(NOTE: Heat energy cooks food, develops mechanical energy to power automobiles, and warms homes.)

C. Chemical

(NOTE: Chemical energy is the energy of life.)

D. Electrical

(NOTE: Electrical energy is the most flexible and is best known for lighting lights, running motors, and providing communications.)

INFORMATION SHEET

E. Nuclear

(NOTE: Nuclear energy, also known as atomic energy, is produced through rearrangement of atoms.)

F. Mechanical

(NOTE: Mechanical energy is contained in every moving object; it is the energy involved in motion.)

IV. **Forms of available energy**

A. Potential

(NOTE: Potential energy is stored energy.)

Examples: Fuel, battery, stretched spring

B. Kinetic

(NOTE: Kinetic energy is energy in motion

Examples: Gasoline burning, wind, flowing water

V. **Types of motion (Transparency 1)**

A. Reciprocating

B. Rotary

C. Linear

VI. **Formula for work — Work** = Force × Distance

(NOTE: Force must be used to measure work for all movement except lifting. Work is measured in foot pounds.)

Example: How much work is accomplished if it takes 80 pounds of force to move a 300 pound box 50 feet?

$W = F \times D$
$W = 80 \times 50$
$W = 4000$ foot pounds

INFORMATION SHEET

VII. **Formula for horsepower** — Horsepower $= \frac{\text{Force} \times \text{distance}}{\text{Time (sec)} \times 550}$ or

$$\frac{\text{Weight} \times \text{distance}}{\text{Time (sec)} \times 550}$$

(NOTE: One horsepower is 550 foot pounds of work done in one second. Force must be used instead of weight in all situations except lifting.)

Example: A 180 pound man climbs a 10 foot flight of stairs in 5 seconds. How much horsepower does he develop?

$$HP = \frac{W \times D}{\text{Time (sec)} \times 550}$$

$$HP = \frac{180 \times 10}{5 \times 550}$$

$$HP = \frac{1800}{2750}$$

HP = .65 horsepower

VIII. **Formula for torque — Torque** = Force × Radius

(NOTE: Unit of measurement is pound feet measured as a force applied to a radius.)

Example: If 25 pounds of force is applied to a wrench 2 feet long, what is the torque?

$T = F \times R$
$T = 25 \times 2$
T = 50 pound feet

IX. **Parts of basic internal combustion engine (Transparency 2)**

A. Cylinder — Hollow tube closed at one end by the cylinder head

B. Piston — Cylindrical object which slides in the tube, fitting tightly to seal other end of tube

C. Rings — Circular devices fitted to the upper end of the piston which seal the piston to the cylinder to control loss of compression and lubricating oil

D. Connecting rod — Rod which connects the crank on the crankshaft to the piston

E. Crankshaft — Main shaft of an engine which, in conjunction with connecting rods, changes reciprocating motion of pistons into rotary motion

(NOTE: The lower end of the connecting rod is connected to offset center portion of crankshaft and must follow the same circular path as shaft.)

INFORMATION SHEET

F. Valve — Movable plug to open and close the cylinder in order to let in air-fuel mixture and to remove the burned fuel from the cylinder

G. Port — Passage behind the valves which conducts fuel and air into and exhaust out of the cylinder

X. **Process by which an internal combustion engine converts chemical energy into rotary motion (Transparency 3)**

A. Gasoline and air are introduced into the upper end of the cylinder

B. Air-fuel mixture is ignited and burned, producing heat energy

C. Heat energy causes the cylinder gases to expand

D. Expansion of the burning gases pushes piston down the cylinder

E. Downward motion of piston transmits force to the crankshaft through the connecting rod to produce rotary motion

(NOTE: Rotary motion is a result of the turning crankshaft.)

XI. **Formula for engine cubic inch displacement (Transparency 4)**

$$\text{Cubic inch displacement} = \frac{\pi \times \text{Bore}^2 \times \text{Stroke}}{4} \times \text{Number of cylinders}$$

Example: An 8-cylinder engine with a 4" bore and a 3 1/2" stroke has how much displacement?

$$\text{CID} = \frac{(3.1416) \times \text{Bore}^2\ (4^2) \times \text{Stroke}\ (3.50)}{4} \times \text{No. of cylinders (8)}$$

$$\text{CID} = \frac{3.1416 \times 4^2 \times 3.5}{4} \times 8$$

$$\text{CID} = 43.98 \times 8$$

CID = 351.85 cubic inch displacement

(NOTE: One liter is equal to 61.02 cubic inches.)

XII. **Formula for compression ratio** — Air volume of cylinder with the piston at BDC divided by volume with piston at TDC (Transparency 5)

Example: Cylinder volume at BDC is 42.35 cu. in. Volume at TDC is 4.45 cu. in. Compression ratio is 9.5 to 1 [42.35 ÷ 4.5 = 9.5:1]

INFORMATION SHEET

XIII. **Types of engine design (Transparencies 6 and 7)**

A. In-line

B. V-type

C. Opposed

D. Radial

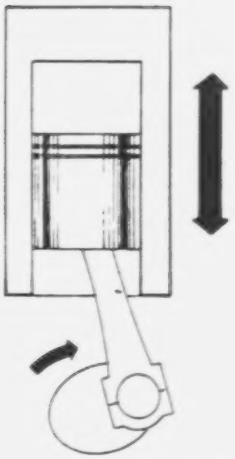
E. Rotary

XIV. **Types of engine cooling systems (Transparency 8)**

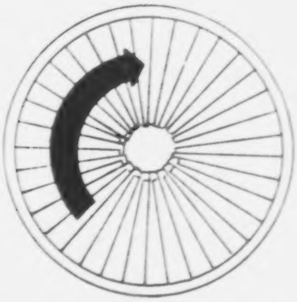
A. Liquid

B. Air

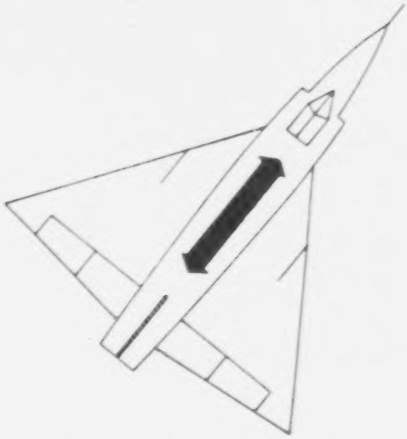
Types of Motion



Reciprocating Input Motion
From a Piston

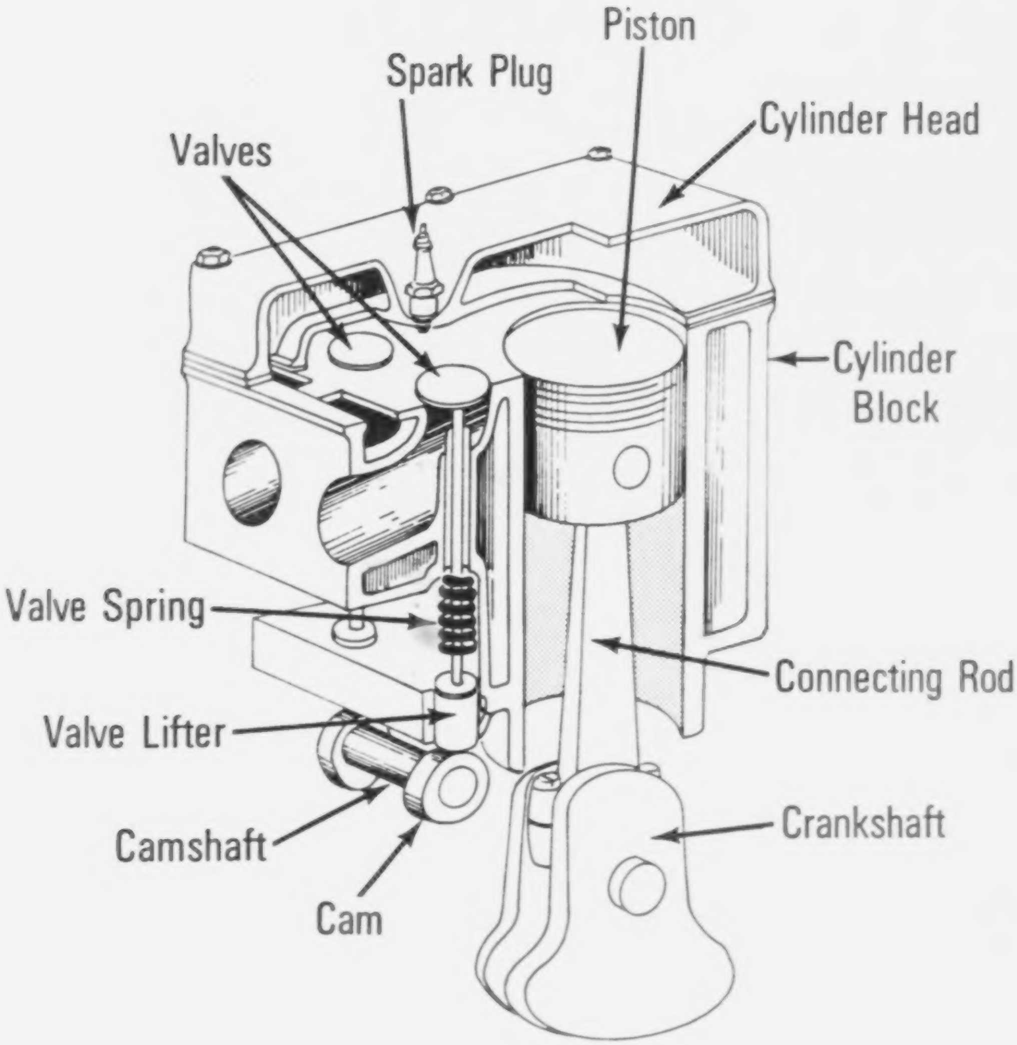


Rotary Input Motion
from a Turbine

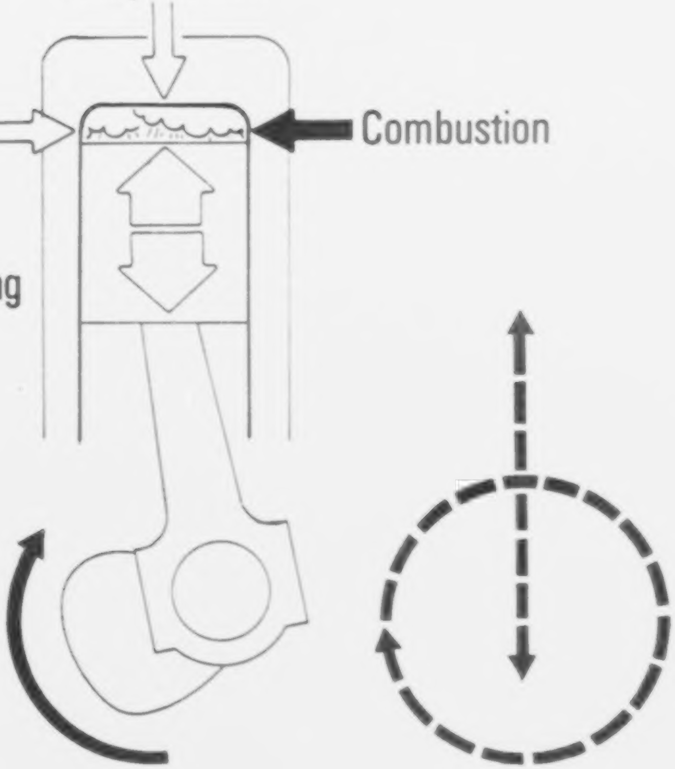


Linear Input Motion
from a Jet

Basic Internal Combustion Engine Parts


Piston
Spark Plug
Cylinder Head
Valves
Cylinder Block
Valve Spring
Connecting Rod
Valve Lifter
Crankshaft
Camshaft
Cam

Chemical Energy to Rotary Motion



Compression

Air–Fuel Mixture

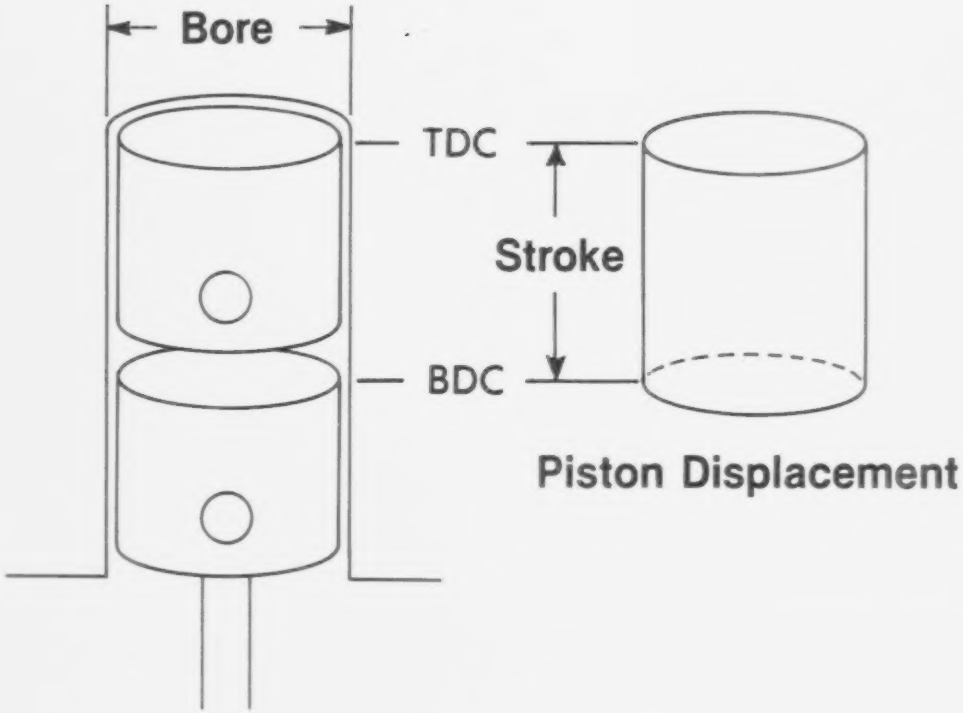
Combustion

Reciprocating Motion

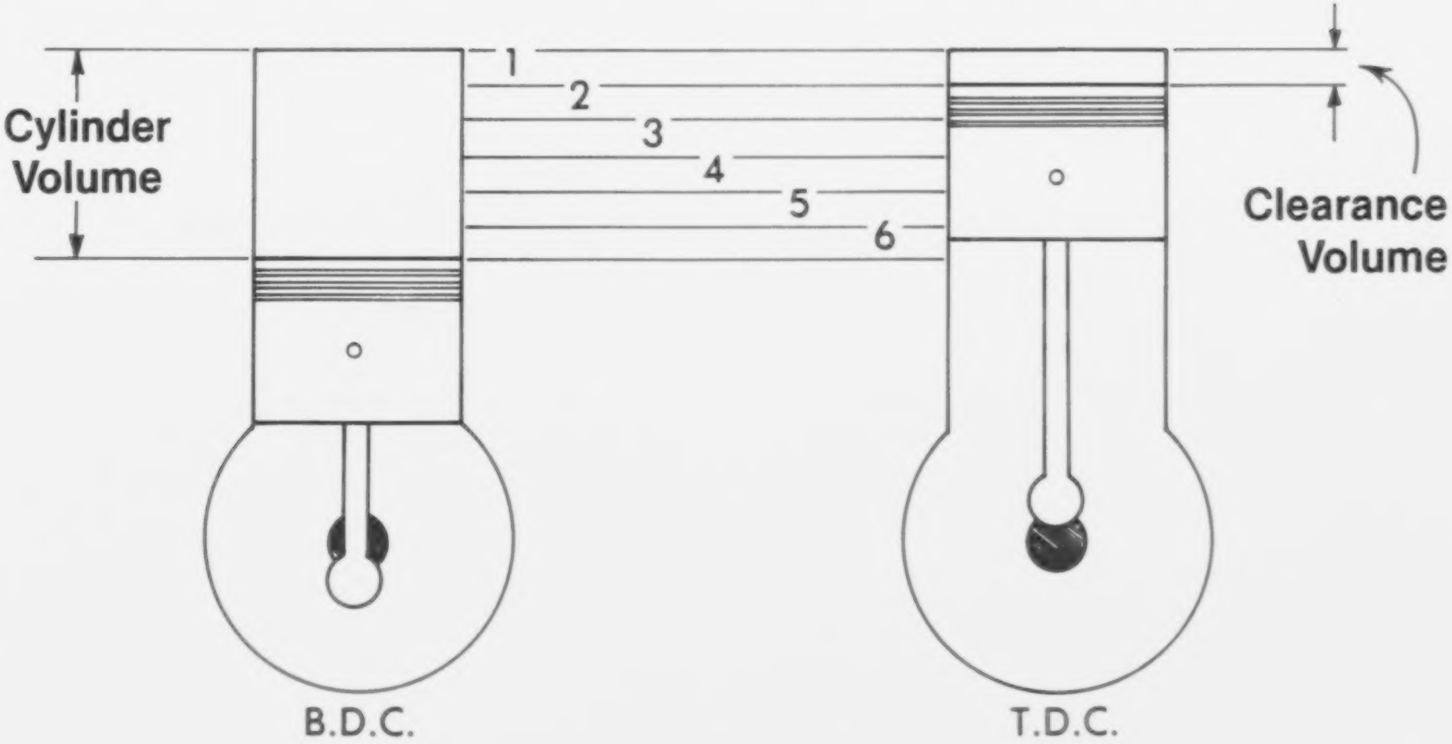
Rotary Motion

Cycles-
Two-or
Four-Stroke

Cubic Inch Displacement


Bore
TDC
Stroke
BDC
Piston Displacement

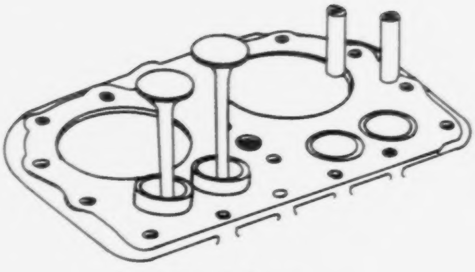
Compression Ratio 6 To 1


Cylinder Volume
1
2
3
4
5
6
Clearance Volume
B.D.C.
T.D.C.

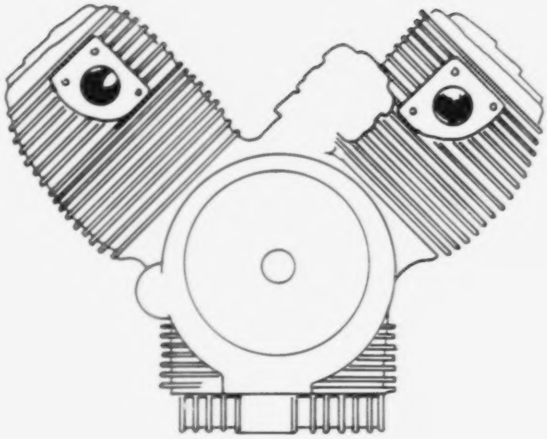
TM 5

SE-43-B

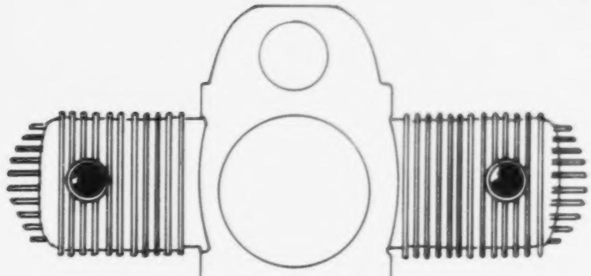
Engine Designs



In-Line



V-Type

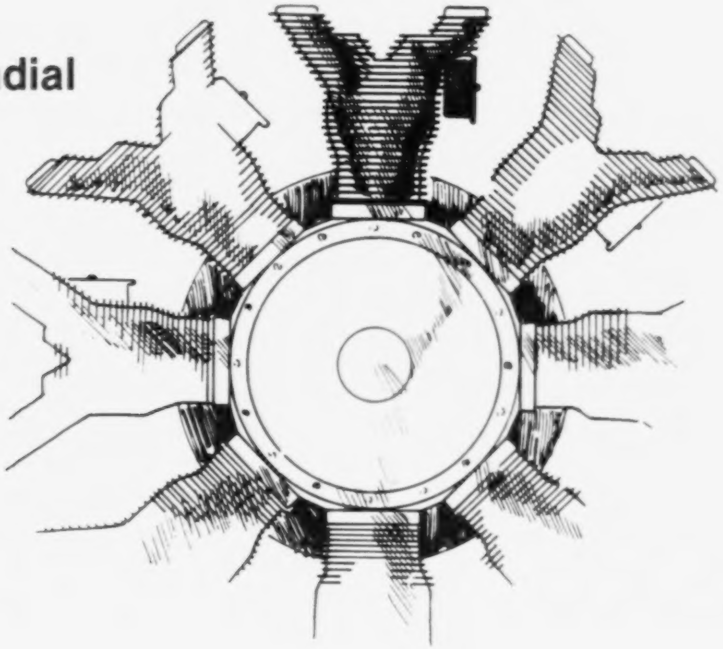


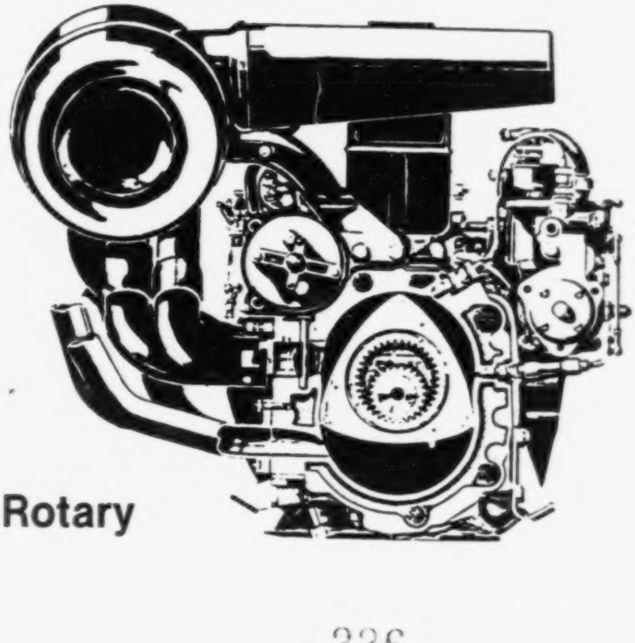
Opposed

Engine Designs

(Continued)

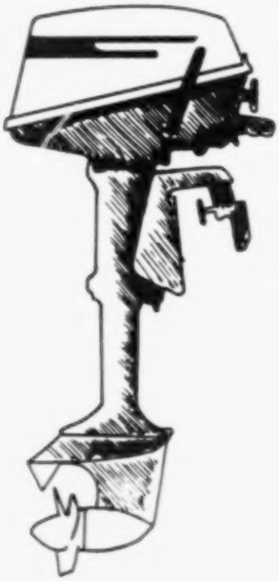
Radial



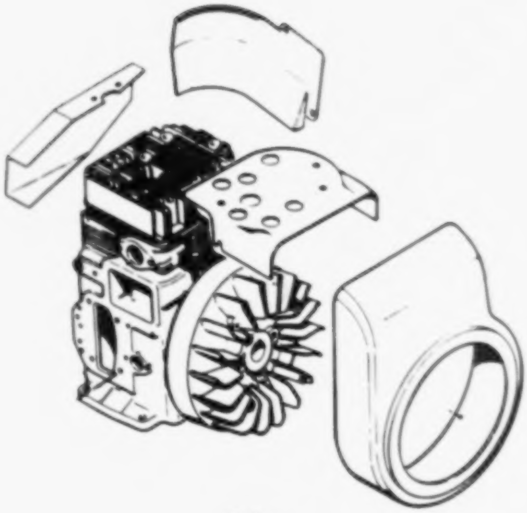


Rotary

Engine Cooling Systems



Liquid



Air

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II-B

ASSIGNMENT SHEET #1 — CALCULATE WORK

Calculate the following problems using the formula for work.

Work = Force × Distance

1. Two men push a 300 pound weight a distance of 50 feet along a warehouse floor. The force necessary to slide the weight is 110 pounds. How much work is accomplished?

2. How much work is accomplished if it takes 92 pounds of force to move a 400 pound object 44 feet?

3. It takes 49 pounds of force to move a 92 pound box 60 feet across the floor. How much work is accomplished?

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II-B

ASSIGNMENT SHEET #2 — CALCULATE HORSEPOWER

Calculate the following problems using the formula for horsepower.

$$HP = \frac{F \times D}{\text{Time (sec)} \times 550}$$

1. A 200 pound man climbs a 40 foot flight of stairs in 20 seconds. How much horsepower does he develop performing the feat?

2. A 1000 pound weight is moved a distance of 60 feet across the floor. The force necessary to move the weight is 200 pounds and the time required to accomplish this is one minute. How much horsepower is required to perform this task?

3. A man pushes a 400 pound weight a distance of 10 feet along the loading dock. The force required to move the weight is 500 pounds. The task is completed in 5 seconds. How much horsepower is produced?

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II-B

ASSIGNMENT SHEET #3 — CALCULATE TORQUE

Calculate the following problems using the formula for torque.

Torque = Force × Radius

1. If a mechanic uses a wrench 8 inches long and applies a 10 pound force to the wrench handle, what is the torque on the bolt?

2. If 15 pounds of force is applied to a wrench 6 inches long, how much is the torque?

3. What is the torque if a force of 8 pounds is applied to a wrench 12 inches long?

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II-B

ASSIGNMENT SHEET #4 — CALCULATE CUBIC INCH DISPLACEMENT

Calculate the following problems using the formula for cubic inch displacement. Round answers to nearest whole number.

$$\text{CID} = \frac{\pi \times \text{Bore}^2 \times \text{Stroke}}{4} \times \text{Number of cylinders}$$

1. What is the CID of a cylinder with a 2-inch bore and a 3-inch stroke?

2. Compute the CID of a 4-cylinder engine with 2.5 inch bore and a 2.48 inch stroke.

3. What is the CID of a 6-cylinder engine with a 1.85-inch bore and a 1.969 inch stroke?

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II-B

ASSIGNMENT SHEET #5 — CALCULATE COMPRESSION RATIO

Calculate the following problems using the formula for compression ratio.

$$\text{Compression Ratio} = \frac{\text{Volume BDC}}{\text{Volume TDC}}$$

1. What is the compression ratio of a cylinder with a volume of 36 cu. in. with the piston at BDC and a TDC volume of 4 cu. in.?

2. Engine A has BDC volume of 16.7 cubic inches and a TDC volume of 2.3 cubic inches. What is the compression ratio?

3. A specific 3 cylinder engine has a total BDC volume of 86 cubic inches and TDC volume of 3 cubic inches in each cylinder. What is the compression ratio of this engine?

4. The maximum practical compression ratio for a specific one cylinder engine is 11.2 to 1. The engine has a BDC volume of 38.77 cubic inches and a TDC volume of 3.5 cubic inches. Is the compression ratio within the practical limits?

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II-B

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. $W = F \times D$
   $W = 110 \times 50$
   W = 5500 foot pounds

2. $W = F \times D$
   $W = 92 \times 44$
   W = 4048 foot pounds

3. $W = F \times D$
   $W = 49 \times 60$
   W = 2940 foot pounds

Assignment Sheet #2

1. $HP = \frac{F \times D}{\text{Time (sec)} \times 550}$
   $HP = \frac{200 \times 40}{20 \times 550}$
   $HP = \frac{8000}{11000}$
   HP = .727 or approx. $^{7}/_{10}$ horsepower

2. $HP = \frac{F \times D}{\text{Time (sec)} \times 550}$
   $HP = \frac{200 \times 60}{60 \times 550}$
   $HP = \frac{12000}{33{,}000}$
   HP = .364 horsepower

3. $HP = \frac{F \times D}{\text{Time (sec)} \times 550}$
   $HP = \frac{500 \times 10}{5 \times 550}$
   $HP = \frac{5000}{2750}$
   HP = 1.82 horsepower

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #3

1. $T = F \times R$
   $T = 10 \times 8$
   $T = 80$ pound inches

2. $T = F \times R$
   $T = 15 \times 6$
   $T = 90$ pound inches

3. $T = F \times R$
   $T = 8 \times 12$
   $T = 96$ pound inches

Assignment Sheet #4

1. $\text{CID} = \left(\frac{3.1416 \times 2^2 \times 3}{4}\right) \times 1$

   $\text{CID} = \left(\frac{3.1416 \times 4 \times 3}{4}\right) \times 1$

   $\text{CID} = \left(\frac{37.6992}{4}\right)$

   $\text{CID} = 9.42$ or 9

2. $\text{CID} = \left(\frac{3.1416 \times 2.5^2 \times 3.75}{4}\right) \times 4$

   $\text{CID} = \left(\frac{3.1416 \times 6.25 \times 2.48}{4}\right) \times 4$

   $\text{CID} = \left(\frac{48.6948}{4}\right) \times 4$

   $\text{CID} = 12.1737 \times 4$

   $\text{CID} = 48.6948$ or 49

ANSWERS TO ASSIGNMENT SHEETS

3. $$\text{CID} = \left(\frac{3.1416 \times 1.85^2 \times 1.969}{4}\right) \times 6$$

$$\text{CID} = \left(\frac{3.1416 \times 3.4225 \times 1.969}{4}\right) \times 6$$

$$\text{CID} = \left(\frac{21.1709}{4}\right) \times 6$$

$$\text{CID} = 5.2927 \times 6$$

$$\text{CID} = 31.7564 \text{ or } 32$$

Assignment Sheet #5

1. $$\begin{array}{r} 9 \\ 4\,\overline{)\,36} \\ 36 \end{array}$$ 9 to 1

2. $$\begin{array}{r} 7.26 \\ 2.3\,\overline{)\,16.700} \\ 161 \\ 60 \\ 46 \\ 140 \\ 138 \\ 2 \end{array}$$ 7.26 to 1

3. $$\begin{array}{r} 28.6 \\ 3\,\overline{)\,86.0} \\ 6 \\ 26 \\ 24 \\ 20 \\ 18 \\ 2 \end{array} \qquad \begin{array}{r} 9.53 \\ 3\,\overline{)\,28.6} \\ 27 \\ 16 \\ 15 \\ 10 \\ 9 \\ 1 \end{array}$$ 9.53 to 1

4. $$\begin{array}{r} 11.07 \\ 3.5\,\overline{)\,38.7700} \\ 35 \\ 37 \\ 35 \\ 270 \\ 245 \\ 25 \end{array}$$ 11.07 to 1 Yes

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II-B

NAME ________________________

TEST

1. Match the terms on the right with their correct definitions. (Terms and definitions are continued on the following page.)

_____a. Any agent that produces or tends to produce motion

_____b. Rate at which work is done

_____c. Ability to do work

_____d. Stored energy

_____e. Measurement of turning effort

_____f. Transmission and control of motion through the use of gears, pulleys, shafts, and other mechanical devices

_____g. Bottom dead center

_____h. To exercise restraining or directing influence over working forces

_____i. Back and forth motion

_____j. Energy in motion

_____k. Relaying of a working force

_____l. Measurement of work accomplished in a given period of time

_____m. Pounds per square inch; most common unit for measuring pressure

_____n. Series of events or operations that happen regularly and lead back to the starting point

_____o. Resistance to relative motion between two bodies in contact

1. Energy
2. Work
3. Force
4. Friction
5. Power
6. Kinetic energy
7. Torque
8. Horsepower
9. Potential energy
10. PSI
11. Cycle
12. TDC
13. Mechanical power
14. Transmission
15. Reciprocating motion
16. BDC
17. Control

TEST

_____p. Results of force overcoming a resistance over a definite distance

_____q. Top dead center

_____r. Total volume of air-fuel compressed by the piston in traveling from BDC to TDC

_____s. Cubic inch displacement

_____t. Action or operation of burning

_____u. Distance the piston moves when traveling from TDC to BDC

_____v. Diameter of the cylinder

18. Stroke
19. Combustion
20. CID
21. Displacement
22. Bore

2. List three characteristics of energy.

a. ____

b. ____

c. ____

3. Select types of energy from the following list by placing an "X" in the appropriate blanks.

_____a. Cosmic

_____b. Light

_____c. Heat

_____d. Nuclear

_____e. Electrical

_____f. Chemical

_____g. Mechanical

4. List two forms of available energy.

a. ____

b. ____

TEST

5. Select types of motion from the following list by placing an "X" in the appropriate blanks.

   _____a. Reciprocating

   _____b. Vertical

   _____c. Rotary

   _____d. Horizontal

   _____e. Linear

6. Calculate the following problem using the formula for work.

   W = F x D

   A boy pushes a 200-pound box a distance of 20 feet along the floor. The force necessary to slide the box is 55 pounds. How much work is accomplished?

7. Calculate the following problem using the formula for torque.

   $$HP = \frac{F \times D}{\text{Time (sec)} \times 550}$$

   Using the problem above, how much horsepower is produced if it takes 20 seconds to slide the box along the floor?

8. Calculate the following problem using the formula for torque.

   T = F x R

   What is the torque if a force of 40 pounds is applied to a wrench two feet long?

TEST

9. Match the parts of a basic internal combustion engine on the right with their correct descriptions.

______a. Hollow tube closed at one end by the cylinder head

______b. Cylindrical object which slides in the tube, fitting tightly to seal other end of tube

______c. Rod which connects the crank on the crankshaft to the piston

______d. Main shaft of an engine which, in conjunction with connecting rods, changes reciprocating motion of pistons into rotary motion

______e. Movable plug to open and close the cylinder in order to let in air-fuel mixture and to remove the burned fuel from the cylinder

______f. Circular devices fitted to the upper end of the piston which seal the piston to the cylinder to control loss of compression and lubricating oil

______g. Passage behind the valves which conducts fuel and air into and exhaust out of the cylinder

1. Port
2. Crankshaft
3. Rings
4. Cylinder
5. Connecting rod
6. Piston
7. Valve

10. Complete the following list of statements concerning the process by which an internal combustion engine converts chemical energy into rotary motion.

a. ____________________ and ____________________ are introduced into the upper end of the cylinder

b. ____________________ mixture is ignited and burned, producing heat energy

c. Heat energy causes the cylinder gases to ____________________

d. Expansion of the burning gases pushes piston down the ____________________

e. Downward motion of piston transmits force to the crankshaft through the connecting rod to produce ____________________ motion

TEST

11. Calculate the following problem using the formula for engine cubic inch displacement.

$$\text{CID} = \frac{\pi \times \text{Bore}^2 \times \text{Stroke}}{4} \times \text{Number of cylinders}$$

What is the cubic inch displacement of a 2-cylinder engine that has a bore of 2.3 and a stroke of 3.2 inches?

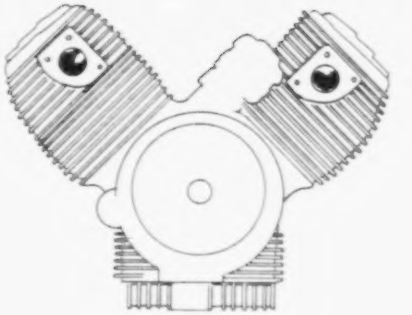
12. Calculate the following problem using the formula for compression ratio.

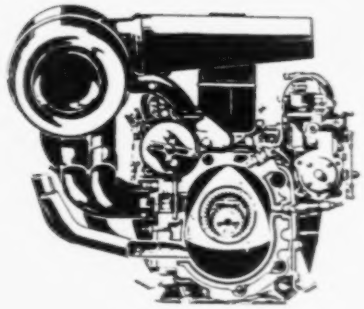
$$\text{Compression ratio} = \frac{\text{Volume BDC}}{\text{Volume TDC}}$$

A specific 2-cylinder engine has a CID of 37 inches. Each cylinder has a BDC volume of 16.5 cubic inches and a TDC volume of 3.3 cubic inches. What is the compression ratio?

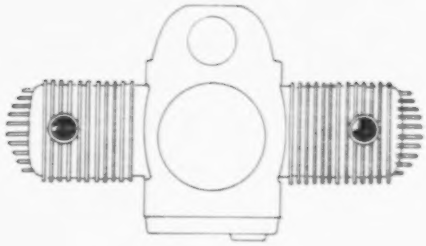
TEST

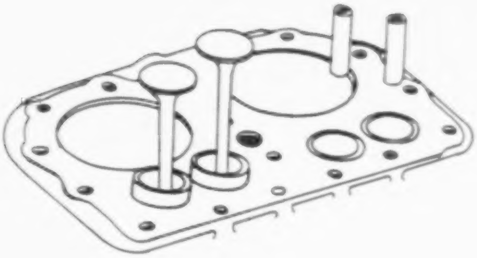
13. Identify types of engine design.





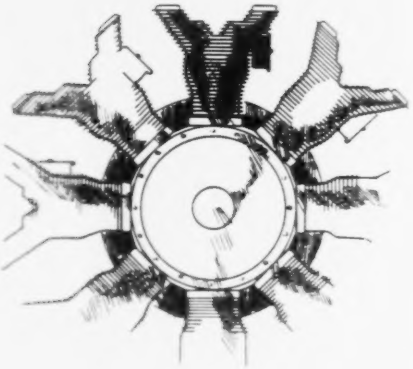
a. ______________________________ b. ______________________________





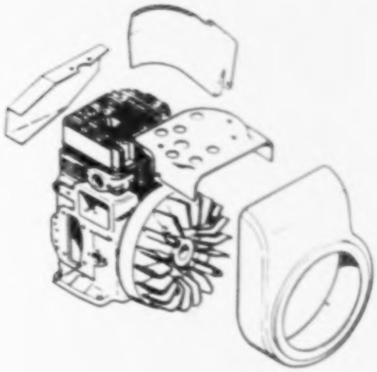
c. ______________________________ d. ______________________________

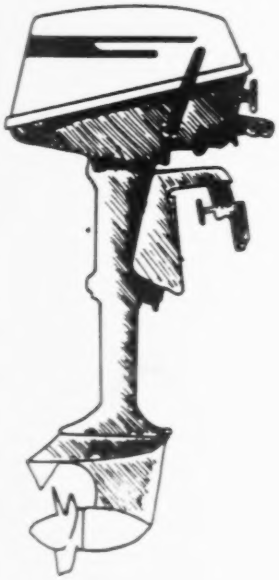
TEST



e. ______________________________

14. Identify types of engine cooling systems.





a. ______________________________ b. ______________________________

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II-B

ANSWERS TO TEST

1.	a.	3	g.	16	m.	10	s.	20
	b.	5	h.	17	n.	11	t.	19
	c.	1	i.	15	o.	4	u.	18
	d.	9	j.	6	p.	2	v.	22
	e.	7	k.	14	q.	12		
	f.	13	l.	8	r.	21		

2. a. Energy is ever present
   b. Energy cannot be created or destroyed
   c. Energy can only be changed from one kind to another

3. b,c,d,e,f,g

4. a. Potential
   b. Kinetic

5. a,c,e

6. W = F × D
   W = 55 lbs × 20 ft
   W = 1100 foot pounds

7. $\text{HP} = \dfrac{\text{F} \times \text{D}}{\text{Time (sec)} \times 550}$

   $\text{HP} = \dfrac{55 \times 20}{20 \times 550}$

   $\text{HP} = \dfrac{1100}{11000}$

   HP = .10

8. T = F × R
   T = 40 × 2
   T = 80 pound feet

9.	a.	4	e.	7
	b.	6	f.	3
	c.	5	g.	1
	d.	2		

10. a. Gasoline, air
    b. Air-fuel
    c. Expand
    d. Cylinder
    e. Rotary

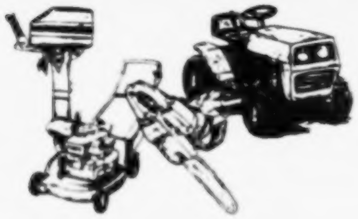
ANSWERS TO TEST

11. 26.6 CID

12. 5 to 1

13. a. V-type
    b. Rotary
    c. Opposed
    d. In-line
    e. Radial

14. a. Air
    b. Liquid



Principles of Operation - Four-Stroke Cycle
Unit III-B

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the components of a four-stroke cycle engine, the parts of a camshaft lobe, and the types of valve arrangements. The student should also be able to complete statements concerning valve timing and overlap. Competency will be demonstrated by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to the principles of operation of a four-stroke cycle engine with their correct definitions.
2. Identify the components of a four-stroke cycle engine.
3. Select true statements concerning the operation of a four-stroke cycle engine.
4. List two factors that determine the firing order of a multi-cylinder engine.
5. Identify the parts of a camshaft lobe.
6. Complete a list of statements concerning valve timing and overlap.
7. Identify types of valve arrangements.

PRINCIPLES OF OPERATION — FOUR-STROKE CYCLE
UNIT III-B

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in unit of instruction

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Integrate the following activities throughout the teaching of this unit:

1. Buy or make a cutaway of small engine to explain the operation of a 4-stroke cycle.
2. Demonstrate the location of components on a live engine.
3. Demonstrate the operation of the four strokes in a cycle.
4. Provide examples of the different types of valve arrangements.
5. Discuss volumaric efficiency.
6. Disassemble an engine so that students can identify individual components and list their functions.
7. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement of the unit.

H. Give test.

I. Evaluate test.

J. Reteach if necessary.

SUGGESTED ACTIVITIES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

   1. TM 1 — Components of a Four-Stroke Cycle Engine
   2. TM 2 — Four-Stroke Cycle
   3. TM 3 — Valve Action on Intake Stroke
   4. TM 4 — Valve Action on Compression Stroke
   5. TM 5 — Valve Action on Power Stroke
   6. TM 6 — Valve Action on Exhaust Stroke
   7. TM 7 — Cam Lobe Contour Design
   8. TM 8 — Valve Timing and Overlap
   9. TM 9 — Valve Arrangements

E. Test

F. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Armstrong, Ivan. *Auto Mechanics, Volume One.* Stillwater, Oklahoma: Oklahoma State Department of Vocational and Technical Education, 1976.

B. *Small Engine Service Repair and Maintenance.* St. Paul, Minnesota: Departments of Agricultural Education and Agricultural Engineering, University of Minnesota, 1968.

C. *Small Gasoline Engines.* University Park, Pennsylvania: College of Agriculture, The Pennsylvania State University, 1969.

D. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

PRINCIPLES OF OPERATION — FOUR-STROKE CYCLE
UNIT III-B

INFORMATION SHEET

I. **Terms and definitions**

   A. Intake stroke — Downward movement of piston which permits fuel-air mixture to enter cylinder

   B. Compression stroke — Upward movement of piston which compresses fuel-air mixture

   C. Power stroke — Downward piston movement caused by spark ignition of compressed fuel-air mixture

   D. Exhaust stroke — Upward piston movement which expels burnt gases from cylinder

   E. Valve — Device for alternately opening and closing a passage

   F. Intake valve — Engine component which opens to allow fuel-air mixture to enter cylinder during intake stroke

   G. Exhaust valve — Engine component which opens during exhaust stroke and allows burnt gases to be expelled from cylinder

   H. Overlap — Brief period when both intake and exhaust valves are open

   I. Cam lobe — Off-center or eccentric enlargement on the camshaft which converts rotary motion to reciprocating motion for operating a valve

   J. Camshaft — Shaft which contains lobes or cams to operate engine valves

   K. Valve lifter or tappet — Push rod or plunger placed between the cam and the valve on an engine

   L. Valve seat — Matched surface upon which the valve rests

   M. Valve spring — Spring attached to a valve to return it to the seat

II. **Components of a four-stroke cycle engine (Transparency 1)**

   A. Cylinder block

   B. Cylinder head

   C. Piston

   D. Connecting rod

INFORMATION SHEET

- E. Crankshaft
- F. Camshaft
- G. Valves
- H. Valve spring
- I. Valve lifter
- J. Cam lobe

III. **Operation of four-stroke cycle engine (Transparencies 2, 3, 4, 5, and 6)**

(NOTE: Four-stroke refers to the number of times the piston moves up and down in the cylinder to complete one cycle of operation. Four-stroke cycle engines are commonly called four cycle engines.)

A. Intake stroke

1. Cycle starts with piston at uppermost position in cylinder (TDC) with intake valve open and exhaust valve closed
2. As the piston moves down the cylinder, it draws air-fuel mixture into the cylinder from the carburetor
3. When the piston reaches the bottom of the cylinder (BDC), the intake valve closes

B. Compression stroke

1. Air-fuel mixture is compressed tightly as the piston moves up the cylinder
2. Compression of the fuel creates heat which prepares the fuel for instant ignition

C. Power stroke

1. As the piston reaches the top of the cylinder on compression stroke, a spark from the ignition system ignites the air-fuel mixture
2. Burning gases expand very rapidly and force the piston down the cylinder

D. Exhaust stroke

1. As the piston reaches the bottom of the cylinder on power stroke, the exhaust valve opens

INFORMATION SHEET

2. Piston travels up the cylinder, forcing the burned gases out of the cylinder into the exhaust manifold

   (NOTE: The complete cycle takes two rotations of the crankshaft or 720 degrees of rotation.)

IV. **Factors that determine the firing order of a multi-cylinder engine**

   A. Design of the crankshaft

   B. Location of the cams on the camshaft

V. **Camshaft lobe (Transparency 7)**

   A. Lobe

   B. Nose

   C. Flank

   D. Base circle

   E. Lift

VI. **Valve timing and overlap (Transparency 8)**

   (NOTE: Valve angles given below are approximated; the actual angles will vary widely depending upon engine design.)

   A. Intake valve — Opens approximately 15 degrees before the intake stroke begins and remains open through intake stroke and 20 degrees into compression stroke

      (NOTE: The intake valve is open approximately 235 degrees of the 720 degree cycle.)

   B. Exhaust valve — Opens approximately 40 degrees before the exhaust stroke begins and remains open through exhaust stroke and 20 degrees into the intake stroke

      (NOTE: The exhaust valve is open approximately 235 degrees of the 720 degree cycle.)

   C. Valve overlap — Both intake and exhaust valves are partially open; the intake valve is starting to open and the exhaust valve is not yet closed

INFORMATION SHEET

VII. **Types of valve arrangements (Transparency 9)**

  A. L-Head

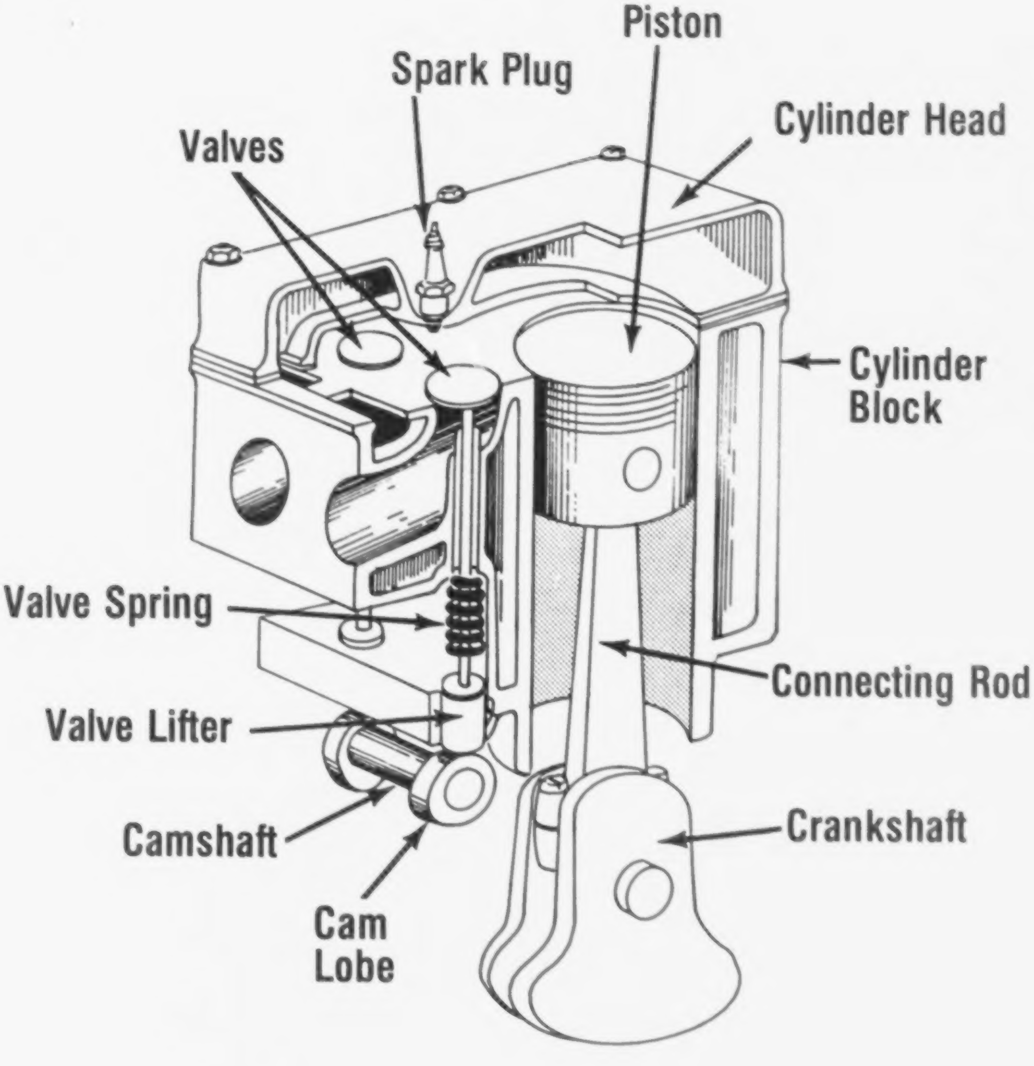
  B. F-Head

  C. T-Head

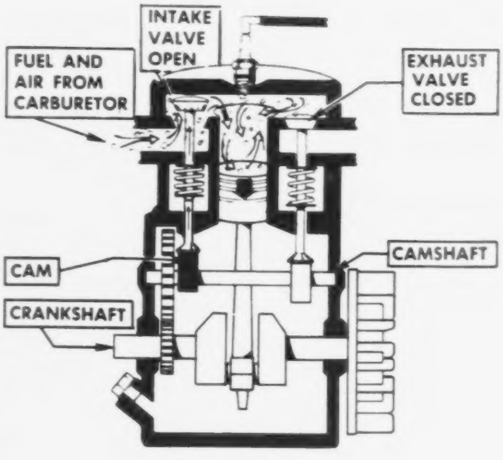
  D. I-Head

  E. Overhead cam

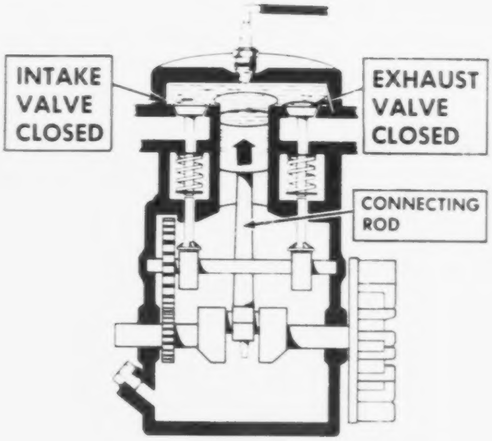
Components of a Four-Stroke Cycle Engine


Piston
Spark Plug
Cylinder Head
Valves
Cylinder Block
Valve Spring
Connecting Rod
Valve Lifter
Crankshaft
Camshaft
Cam Lobe

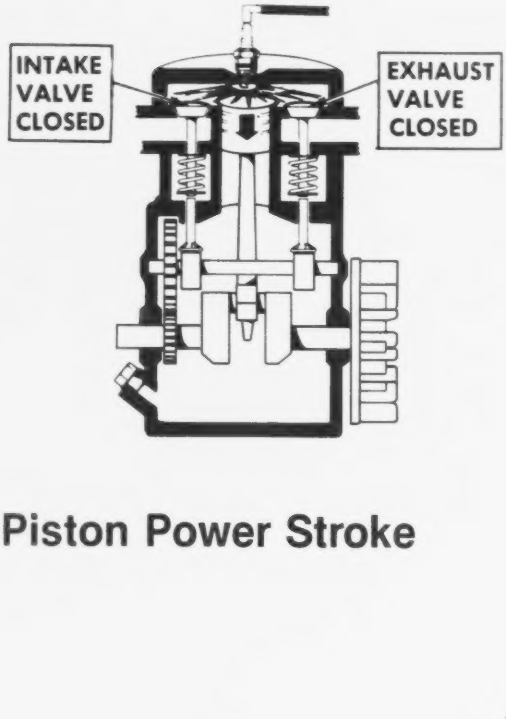
Four-Stroke Cycle


INTAKE VALVE OPEN
FUEL AND AIR FROM CARBURETOR
EXHAUST VALVE CLOSED
CAM
CAMSHAFT
CRANKSHAFT

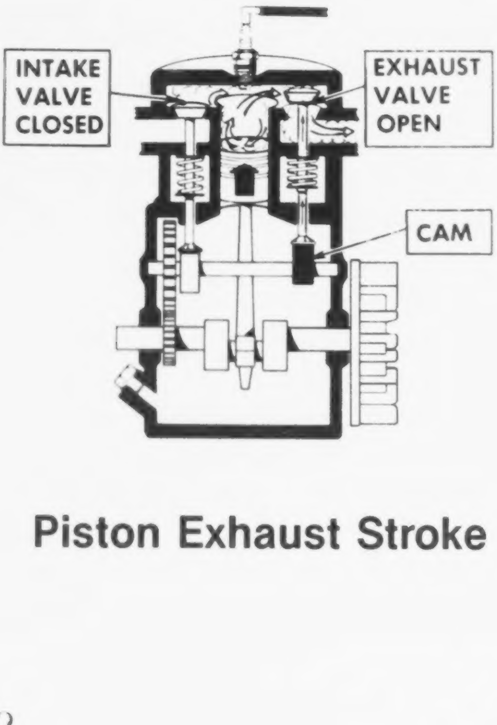
Piston Intake Stroke


INTAKE VALVE CLOSED
EXHAUST VALVE CLOSED
CONNECTING ROD

Piston Compression Stroke

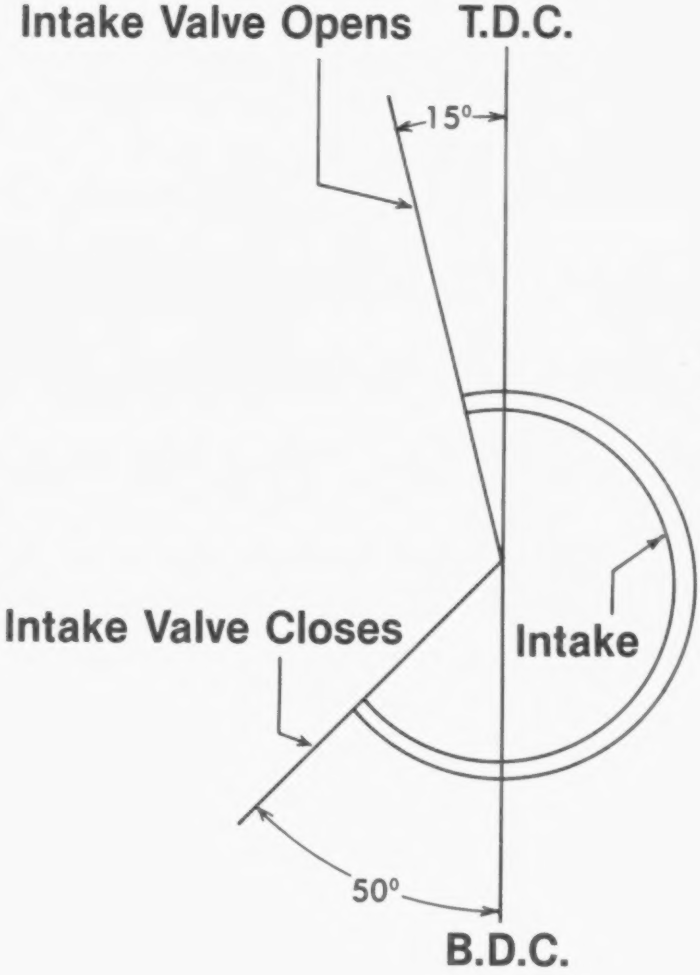

INTAKE VALVE CLOSED
EXHAUST VALVE CLOSED

Piston Power Stroke

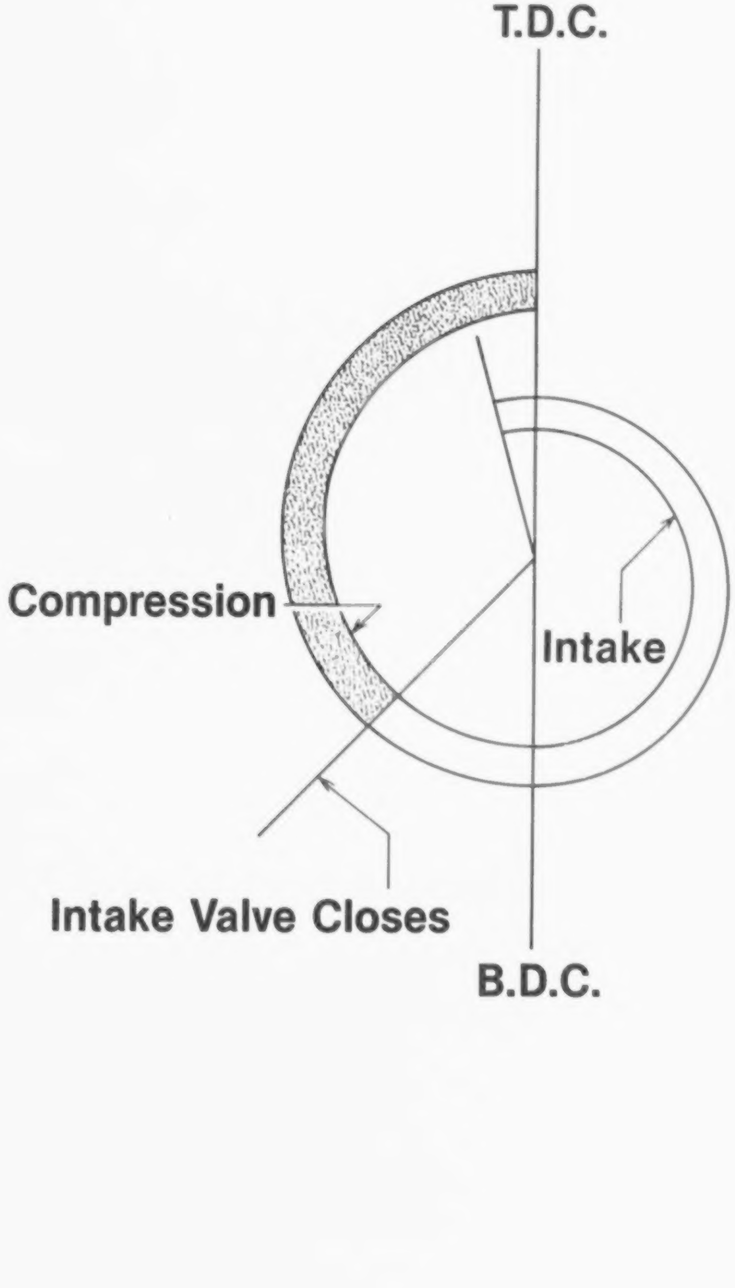

INTAKE VALVE CLOSED
EXHAUST VALVE OPEN
CAM

Piston Exhaust Stroke

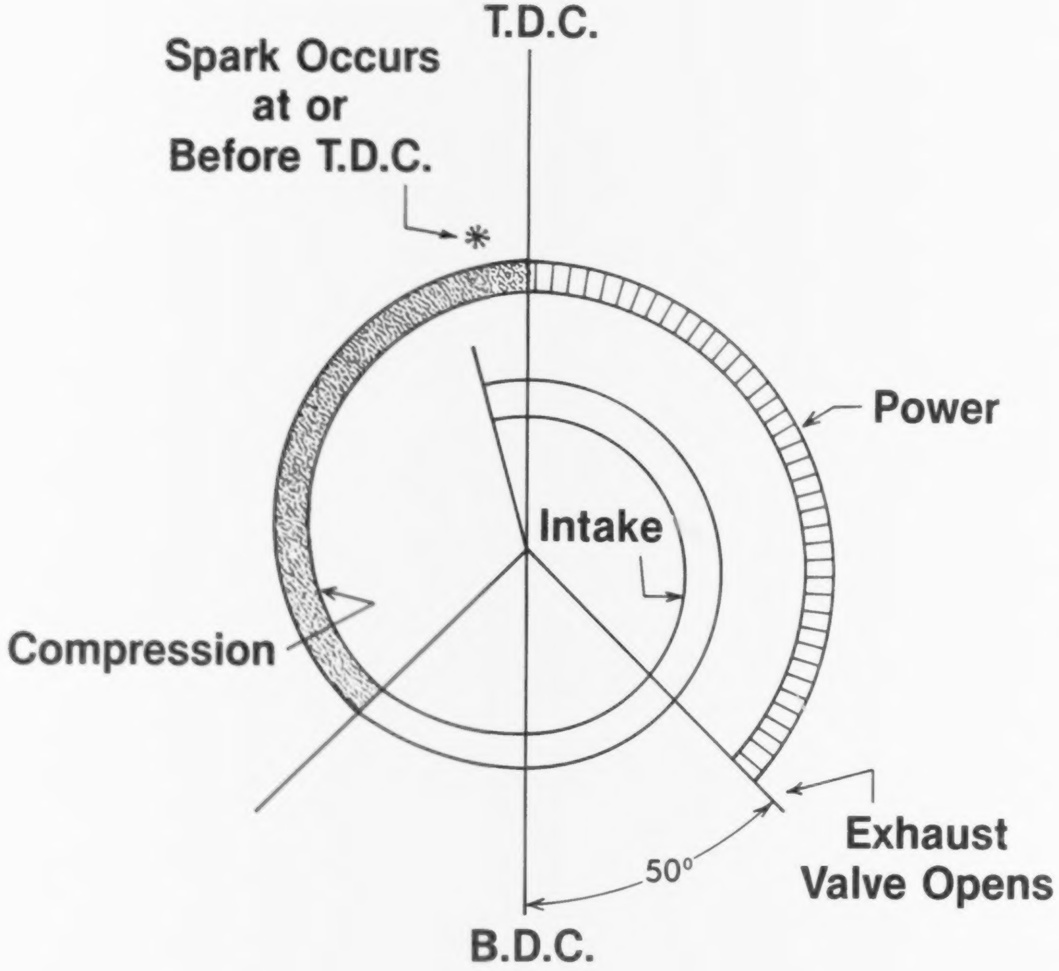
Valve Action on Intake Stroke


Intake Valve Opens
T.D.C.
15°
Intake Valve Closes
Intake
50°
B.D.C.

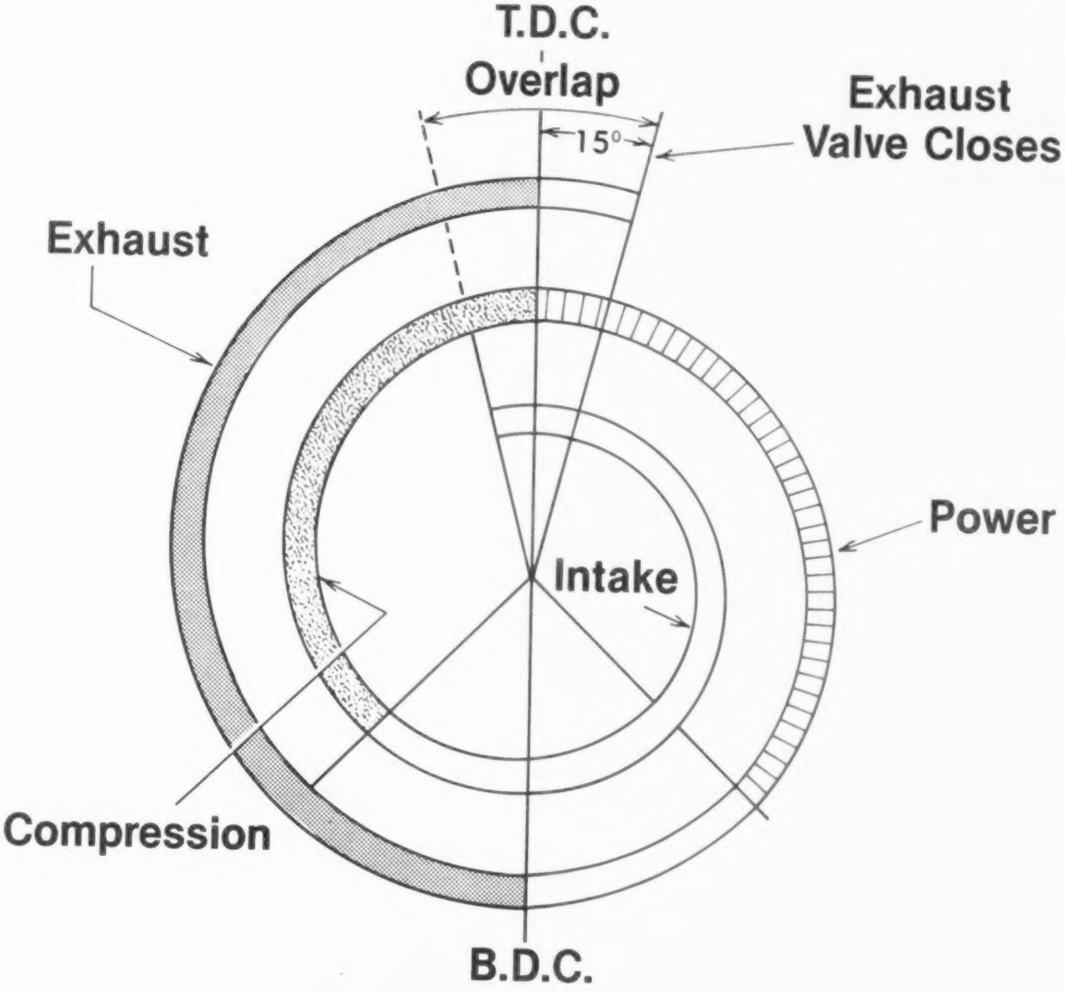
Valve Action on Compression Stroke


T.D.C.
Compression
Intake
Intake Valve Closes
B.D.C.

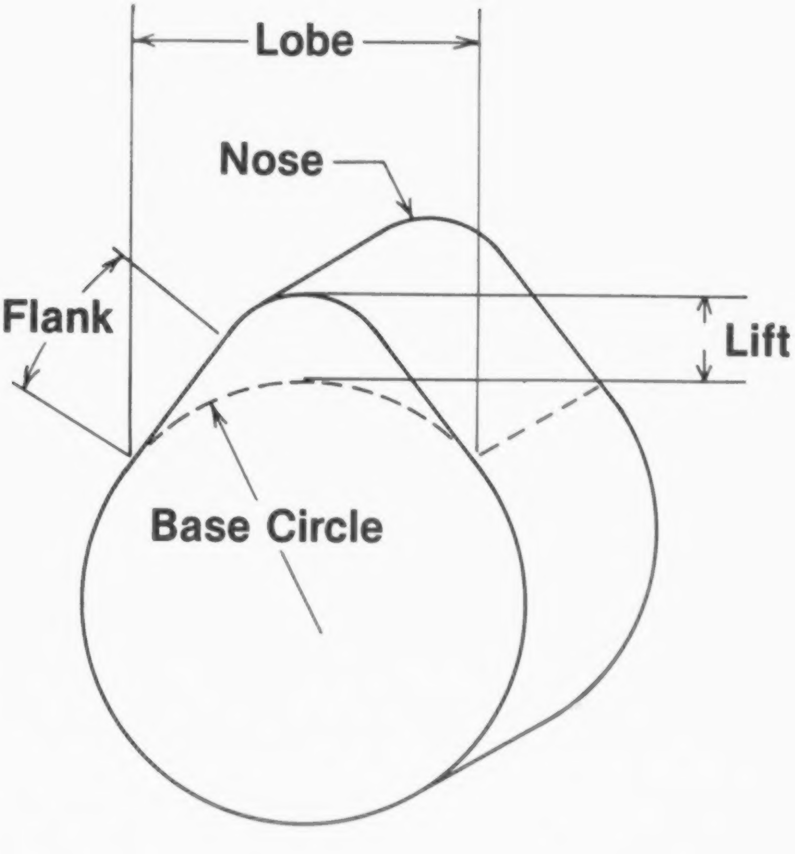
Valve Action on Power Stroke


T.D.C.
Spark Occurs at or Before T.D.C.
*
Power
Intake
Compression
50°
Exhaust Valve Opens
B.D.C.

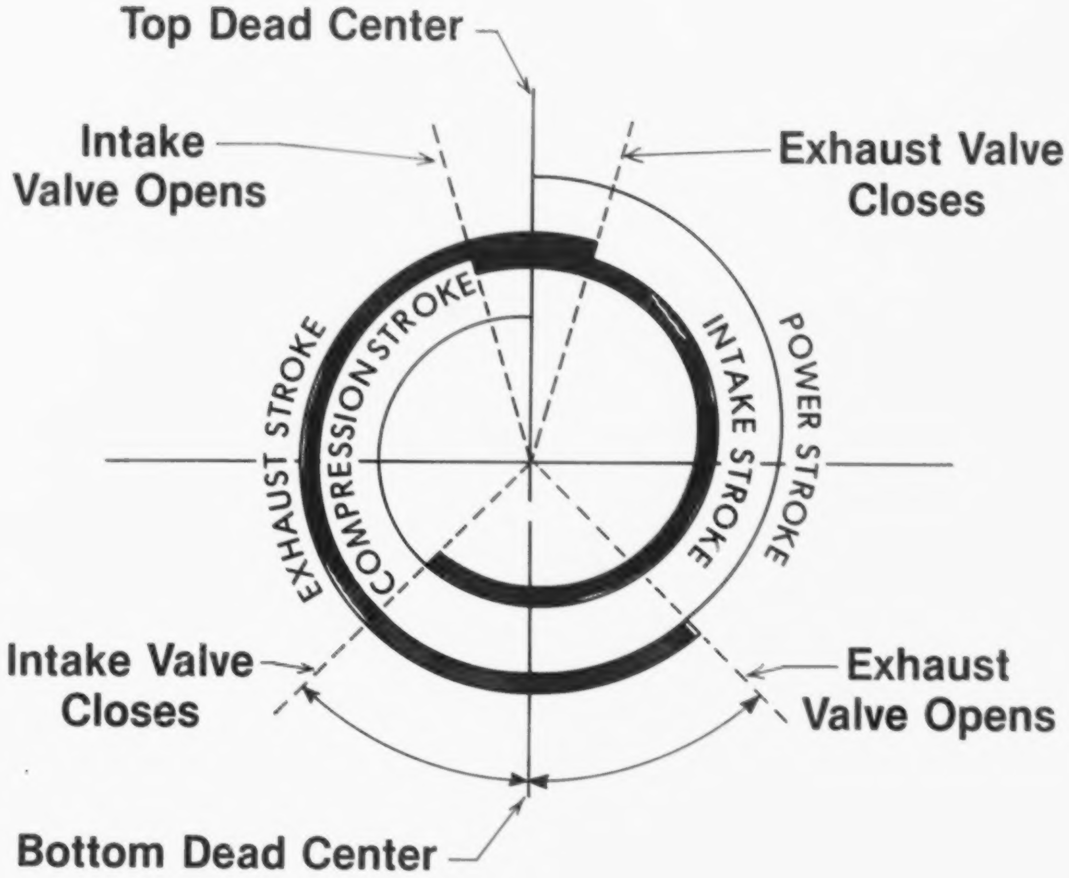
Valve Action on Exhaust Stroke


T.D.C.
Overlap
15°
Exhaust Valve Closes
Exhaust
Power
Intake
Compression
B.D.C.

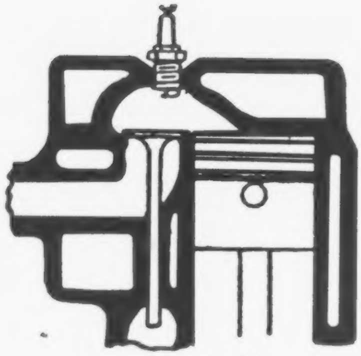
Cam Lobe Contour Design


Lobe
Nose
Flank
Lift
Base Circle

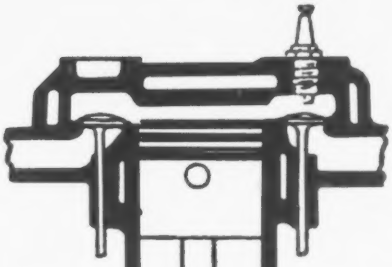
Valve Timing and Overlap


Top Dead Center
Intake Valve Opens
Exhaust Valve Closes
COMPRESSION STROKE
EXHAUST STROKE
INTAKE STROKE
POWER STROKE
Intake Valve Closes
Exhaust Valve Opens
Bottom Dead Center

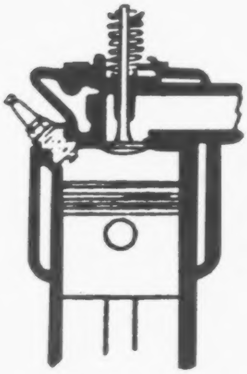
Valve Arrangements



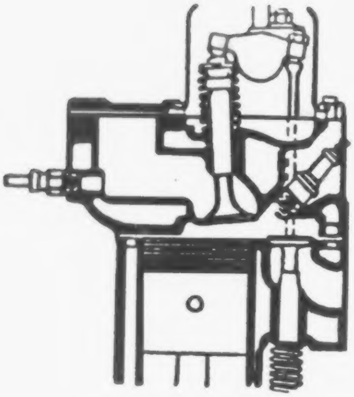
L-Head



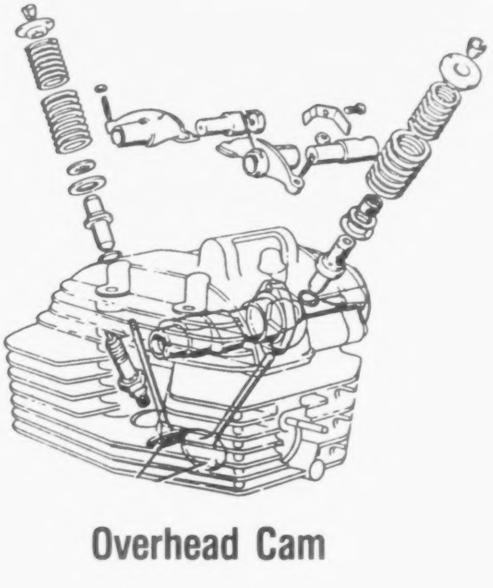
T-Head



I-Head



F-Head



Overhead Cam

PRINCIPLES OF OPERATION — FOUR-STROKE CYCLE
UNIT III-B

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

______a. Spring attached to a valve to return it to the seat

______b. Device for alternately opening and closing a passage

______c. Off-center or eccentric enlargement on the camshaft which converts rotary motion to reciprocating motion for operating a valve

______d. Brief period when both intake and exhaust valves are open

______e. Upward movement of piston which compresses fuel-air mixture

______f. Downward movement of piston which permits fuel-air mixture to enter cylinder

______g. Push rod or plunger placed between the cam and the valve on an engine

______h. Matched surface upon which the valve rests

______i. Shaft which contains lobes or cams to operate engine valves

______j. Engine component which opens during exhaust stroke and allows burnt gases to be expelled from cylinder

______k. Upward piston movement which expels burnt gases from cylinder

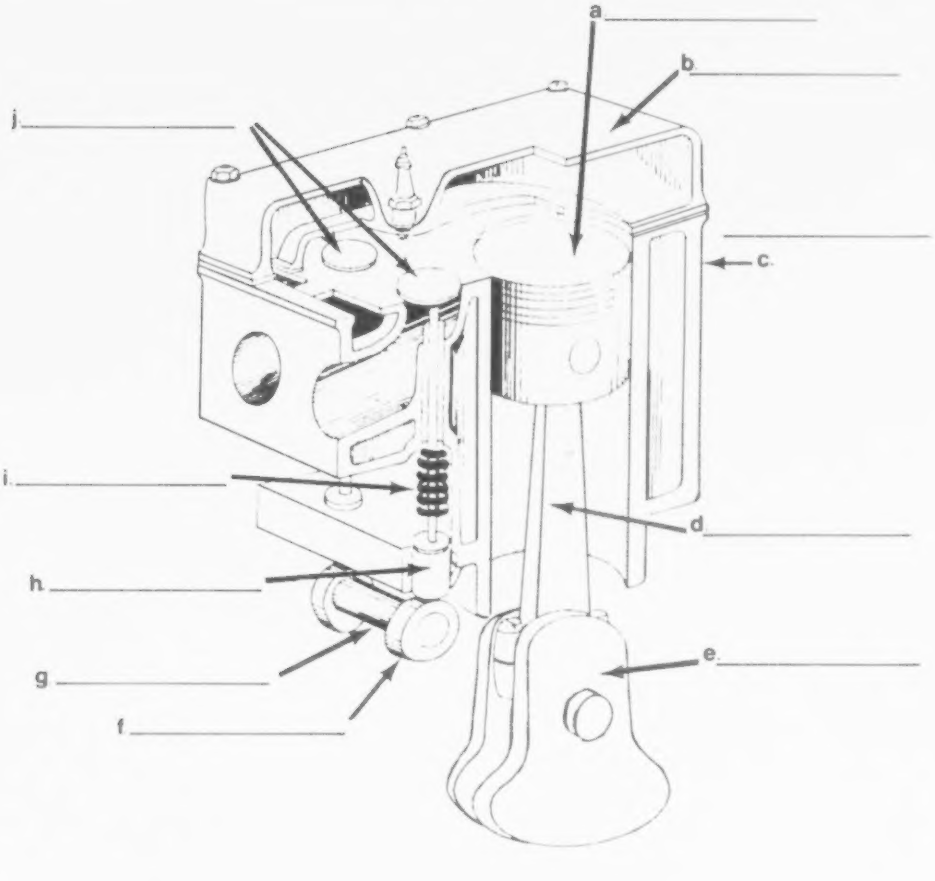
______l. Downward piston movement caused by spark ignition of compressed fuel-air mixture

______m. Engine component which opens to allow fuel-air mixture to enter cylinder during intake stroke

1. Exhaust
2. Power Stroke
3. Valve seat
4. Camshaft
5. Intake stroke
6. Cam lobe
7. Valve
8. Valve spring
9. Intake valve
10. Overlap
11. Compression stroke
12. Exhaust stroke
13. Valve lifter or tappet

TEST

2. Identify the components of a four-stroke cycle engine.


a.
b.
c.
d.
e.
f.
g.
h.
i.
j.

TEST

3. Select true statements concerning the operation of a four-stroke cycle engine by placing an "X" in the appropriate blanks.

   a. Intake stroke

      _____1) Cycle starts with piston at uppermost position in cylinder (TDC) with intake valve closed and exhaust valve open

      _____2) As the piston moves down the cylinder, it draws air-fuel mixture into the cylinder from the carburetor

      _____3) When the piston reaches the bottom of the cylinder (BDC), the exhaust valve closes

   b. Compression stroke

      _____1) Air-fuel mixture is compressed tightly as the piston moves down the cylinder

      _____2) Compression of the fuel creates heat which prepares the fuel for instant ignition

   c. Power stroke

      _____1) As the piston reaches the top of the cylinder on compression stroke, a spark from the ignition system ignites the air-fuel mixture

      _____2) Burning gases expand very rapidly and force the piston down the cylinder

   d. Exhaust stroke

      _____1) As the piston reaches the top of the cylinder on power stroke, the exhaust valve closes

      _____2) Piston travels up the cylinder, forcing the burned gases out of the cylinder into the exhaust manifold

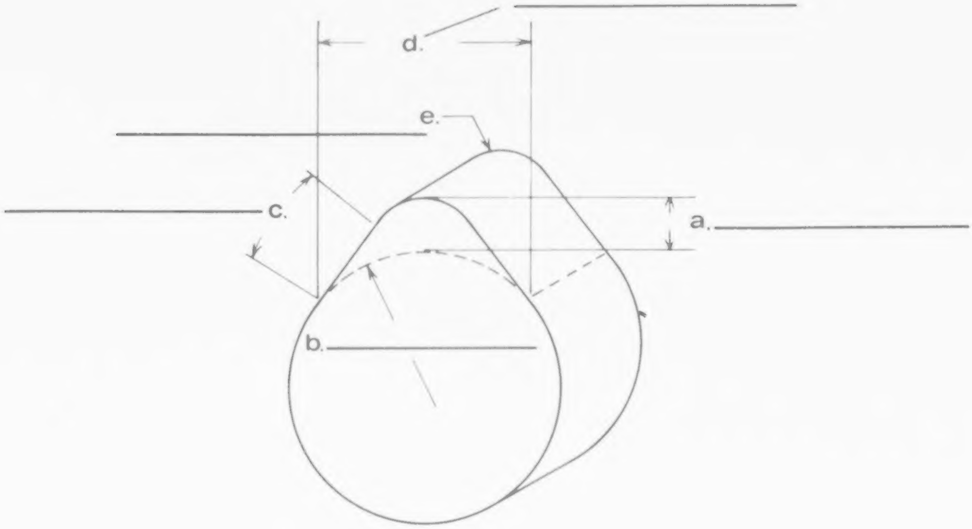
4. List two factors that determine the firing order of a multi-cylinder engine.

   a. ____

   b. ____

TEST

5. Identify the parts of a camshaft lobe.



6. Complete the following list of statements concerning valve timing and overlap by correctly filling in the blanks.

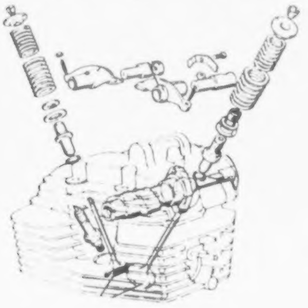
   a. Intake valve — Opens approximately 15 degrees before the intake stroke begins and remains open through intake stroke and 20 degrees into ______________________ stroke

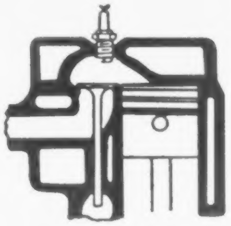
   b. Exhaust valve — Opens approximately 40 degrees before the exhaust stroke begins and remains open through exhaust stroke and 20 degrees into the ______________________ stroke

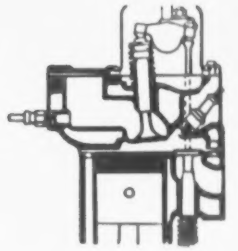
   c. Valve overlap — Both intake and exhaust valves are ______________________; the intake valve is starting to open and the exhaust valve is not yet closed

TEST

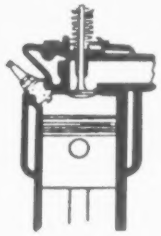
7. Identify the types of valve arrangements.

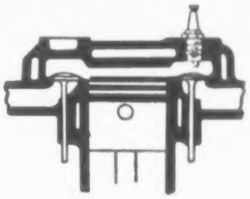






a. ______________________ b. ______________________ c. ______________________





d. ______________________________ e. ______________________________

PRINCIPLES OF OPERATION — FOUR-STROKE CYCLE
UNIT III-B

ANSWERS TO TEST

1. a. 8
   b. 7
   c. 6
   d. 10
   e. 11
   f. 5
   g. 13
   h. 3
   i. 4
   j. 1
   k. 12
   l. 2
   m. 9

2. a. Piston
   b. Cylinder head
   c. Cylinder block
   d. Connecting rod
   e. Crankshaft
   f. Cam lobe
   g. Camshaft
   h. Valve lifter
   i. Valve spring
   j. Valves

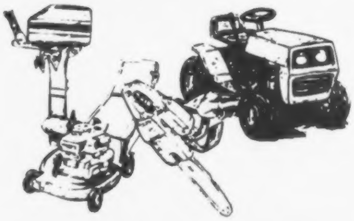
3. a. 2
   b. 2
   c. 1,2
   d. 2

4. a. Design of the crankshaft
   b. Location of the cams on the camshaft

5. a. Lift
   b. Base circle
   c. Flank
   d. Lobe
   e. Nose

6. a. Compression
   b. Intake
   c. Partially open

7. a. Overhead cam
   b. L-Head
   c. F-Head
   d. I-Head
   e. T-Head



Principles of Operation - Two-Stroke Cycle
Unit IV-B

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the components of a basic two-stroke cycle engine and list features which make a two-stroke cycle engine preferable for many applications. Competency will be demonstrated by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to two-stroke cycle engines with their correct definitions.
2. Identify the components of a basic two-stroke cycle engine.
3. Select true statements concerning the operation of a two-stroke cycle engine.
4. Identify the types of valves that may be used in two-stroke cycle engines.
5. Select the factors which determine timing on a two-stroke cycle engine.
6. Distinguish between cross-scavenged and loop-scavenged two-stroke cycle engines.
7. List features which make a two-stroke engine preferable for many applications.
8. Complete a list of statements concerning the importance of correct exhaust system design on a two-stroke cycle engine.

PRINCIPLES OF OPERATION — TWO-STROKE CYCLE
UNIT IV-B

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Integrate the following activities throughout the teaching of this unit:

1. Check with local shops for engines which may be used in class activities.
2. Buy or make a cutaway of small engine to explain the operation of a 2-stroke cycle.
3. Demonstrate the location of components on a live engine.
4. Disassemble an engine so that students can identify individual components and list their functions.
5. Provide examples of reed and rotary valves.
6. Provide examples of cross-scavenged and loop-scavenged engines.
7. Demonstrate the use of correct and incorrect exhaust system components.
8. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement of the unit.

H. Give test.

I. Evaluate test.

SUGGESTED ACTIVITIES

J. Reteach if necessary.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

 1. TM 1 — Two-Stroke Cycle Engine
 2. TM 2 — Operation of the Two-Stroke Cycle Engine
 3. TM 3 — Reed Valves
 4. TM 4 — Rotary Valves and Piston Port
 5. TM 5 — Timing Essentials
 6. TM 6 — Design Variations
 7. TM 7 — Exhaust System Design

E. Test

F. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Roth, Alfred C. and Ronald J. Baird. *Small Gas Engines.* South Holland, Illinois: The Goodheart-Wilcox Company, Inc., 1975.

B. *Small Engine Service Manual.* Eleventh Edition. Kansas City, Missouri: Technical Publications Division, Intertec Publishing Corporation, 1976.

C. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

PRINCIPLES OF OPERATION — TWO-STROKE CYCLE
UNIT IV-B

INFORMATION SHEET

I. **Terms and definitions**

A. Exhaust port — Openings in the cylinder wall which allows the exhaust to escape

B. Transfer port — Passage which allows movement of the fuel-air mixture from the crankcase into the combustion chamber

C. Rotary valve — Flat circular plate with a section of the plate cut away that operates between the carburetor and the crankcase

D. Reed valve (leaf valve) — One way valve made of spring steel which allows the fuel-air mixture to flow in one direction only

E. Crankcase pressure — Pressure built up in the crankcase by the downward movement of the piston

(NOTE: This causes the fuel-air mixture to move into the combustion chamber.)

F. Crankcase vacuum — Negative crankcase pressure created when piston moves upward in cylinder

G. Expansion chamber — Exhaust system specially designed to produce maximum horsepower at a specific RPM range

II. **Components of a basic two-stroke cycle engine (Transparency 1)**

(NOTE: The two-stroke cycle engine may be referred to as a two-cycle engine.)

A. Cylinder

B. Piston

C. Transfer port

D. Exhaust port

E. Crankshaft

F. Connecting rod

G. Cylinder head

H. Crankcase

(NOTE: The cylinder and cylinder head may be made as one piece.)

INFORMATION SHEET

III. **Operation of a two-stroke cycle engine (Transparency 2)**

- A. Piston moves up in cylinder drawing fuel-air mixture into crankcase
- B. Piston moves down cylinder, pressurizing mixture in crankcase
- C. Piston moves past transfer port allowing pressurized mixture to move into combustion chamber
- D. Piston moves up in cylinder again
  1. Compresses fuel-air mixture
  2. Draws more fuel-air mixture into crankcase
- E. Spark plug fires compressed mixture
- F. Combustion moves piston back down cylinder
  1. Piston uncovers exhaust port as it nears bottom of stroke allowing exhaust to escape
  2. Piston uncovers transfer port as it moves nearer bottom of stroke allowing fresh charge of fuel-air to enter combustion chamber
- G. Piston starts back up cylinder closing both transfer and exhaust ports

IV. **Valves used in two-stroke cycle engines (Transparencies 3 and 4)**

- A. Reed valve
- B. Rotary valve
- C. Piston port

V. **Factors which determine timing on two-stroke cycle engines (Transparency 5)**

- A. Location of intake port
- B. Location of transfer port
- C. Location of exhaust port

INFORMATION SHEET

VI. **Design variations (Transparency 6)**

A. Cross-scavenged

1. Special piston shape acts as baffle
2. Deflected fuel air charge moves upward in cylinder
3. Charge prevented from going straight out exhaust port

B. Loop-scavenged

1. Transfer ports shaped and located so that incoming fuel-air mixture swirls
2. Controlled flow of gas helps exhaust out and new charge to enter

VII. **Features which make a two-stroke cycle engine preferable for many applications**

A. Simple design

B. Light weight

C. Smaller size for equivalent horsepower

D. Adequate lubrication in any position

E. Continuous supply of new, clean oil to all moving parts

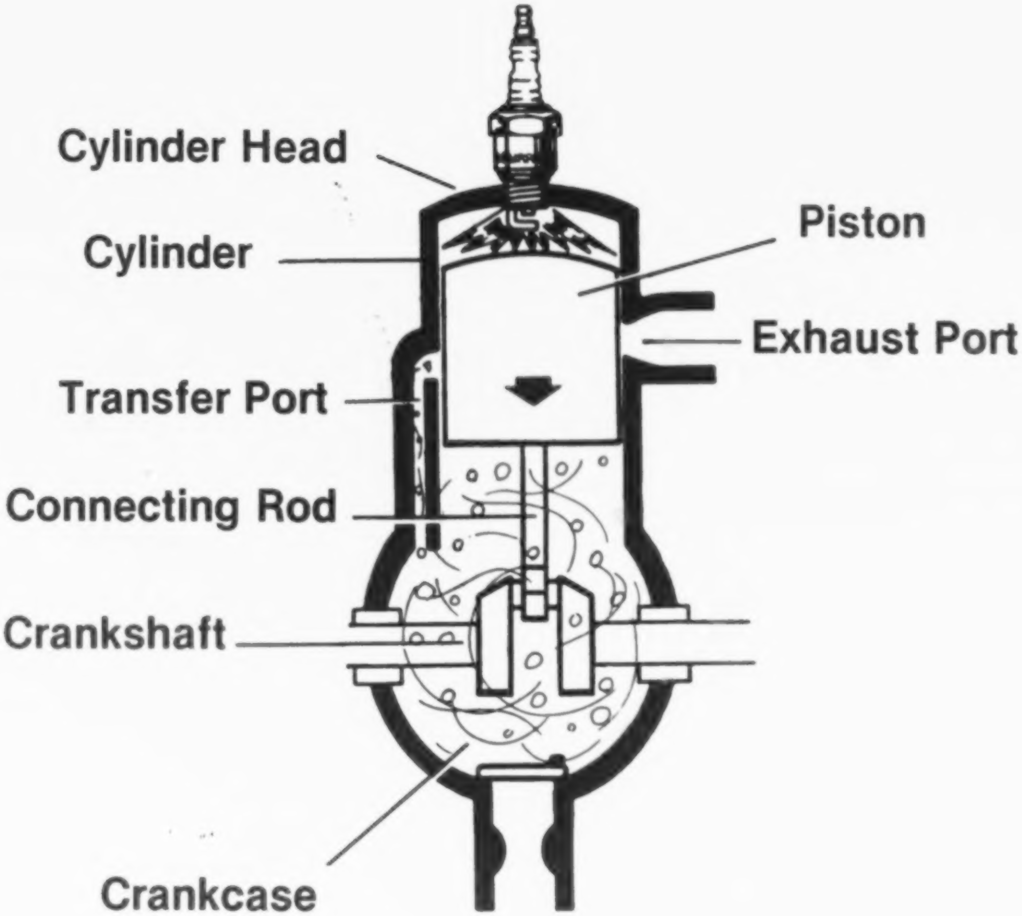
VIII. **Correct exhaust system design (Transparency 7)**

A. Scavenges all exhaust from combustion chamber

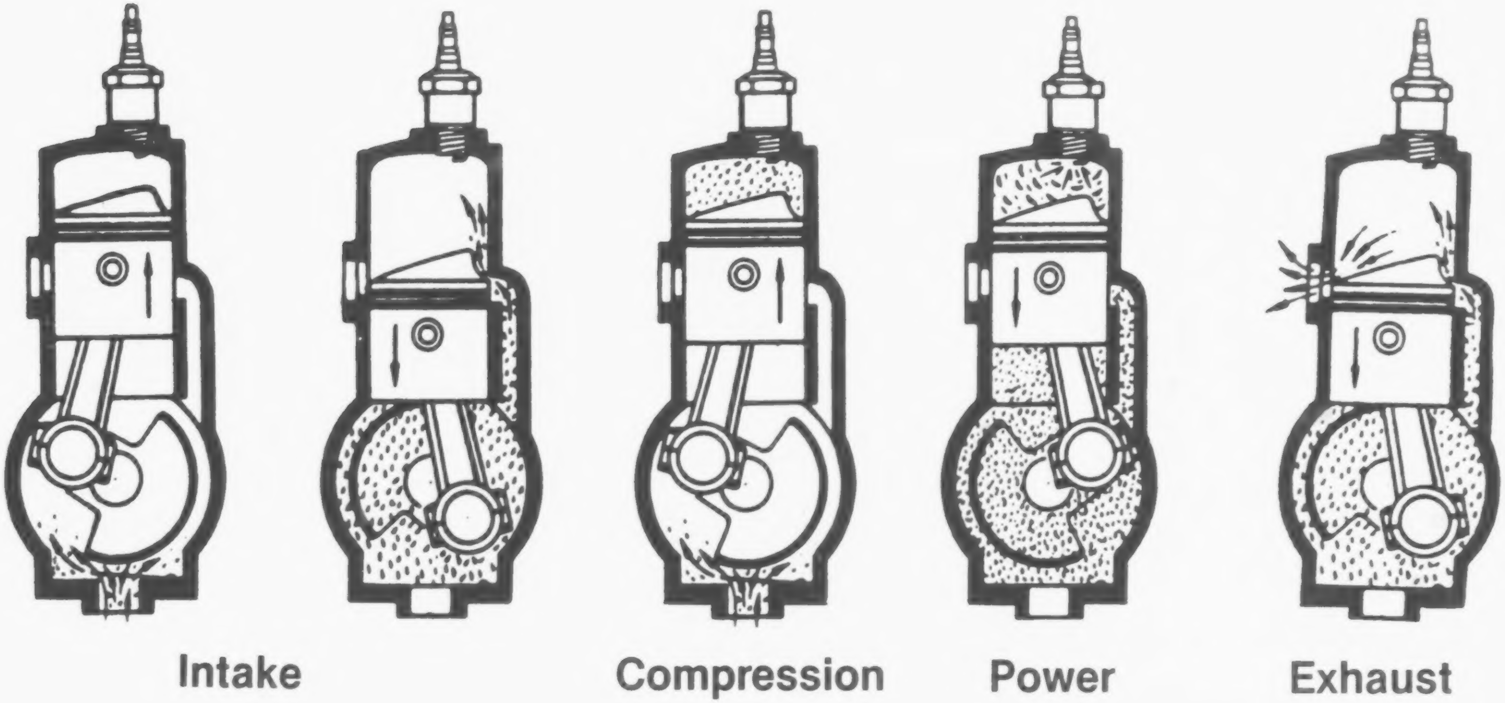
B. Allows new fuel charge to move into combustion chamber rapidly

C. Sound waves hold fuel charge momentarily while exhaust port is open

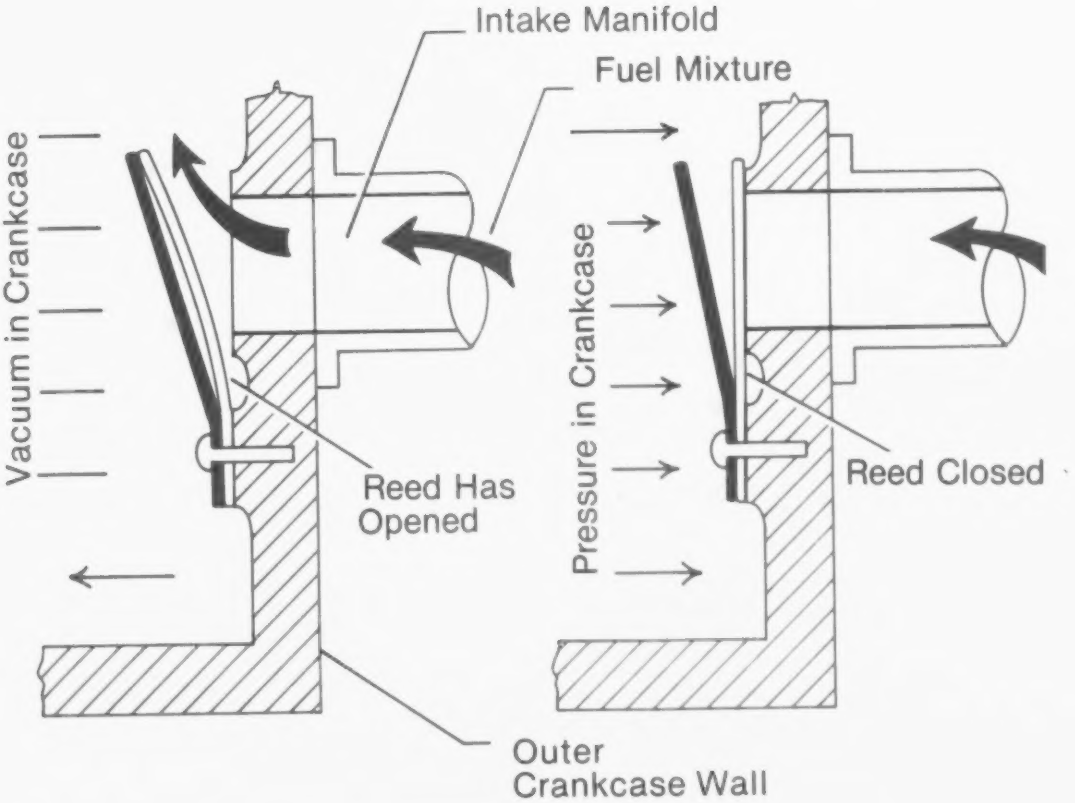
Two-Stroke Cycle Engine

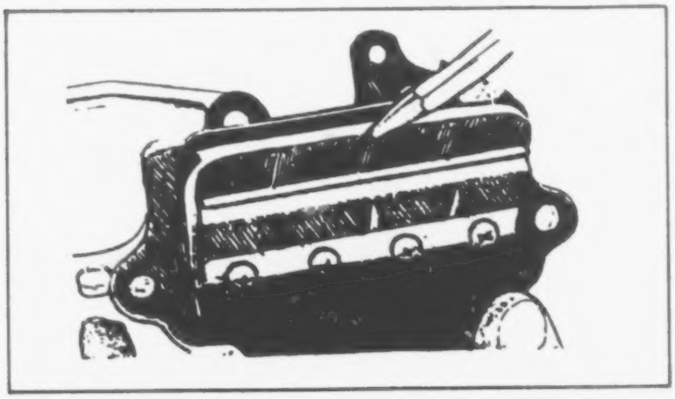

Cylinder Head
Cylinder
Piston
Exhaust Port
Transfer Port
Connecting Rod
Crankshaft
Crankcase

Operation of the Two-Stroke Cycle Engine


Intake
Compression
Power
Exhaust

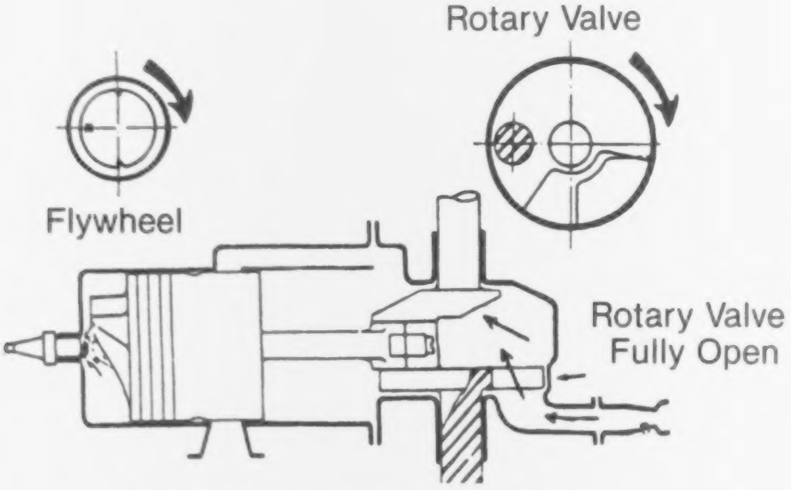
Reed Valves


Intake Manifold
Fuel Mixture
Vacuum in Crankcase
Pressure in Crankcase
Reed Has Opened
Reed Closed
Outer Crankcase Wall

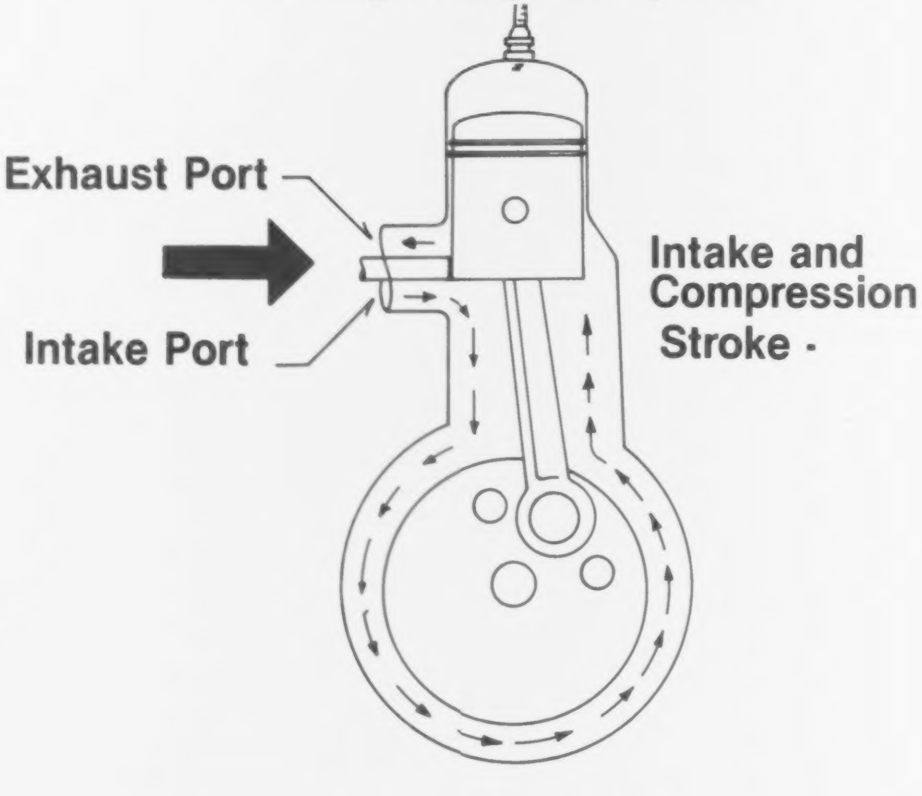


Frontal View of Reed Valve

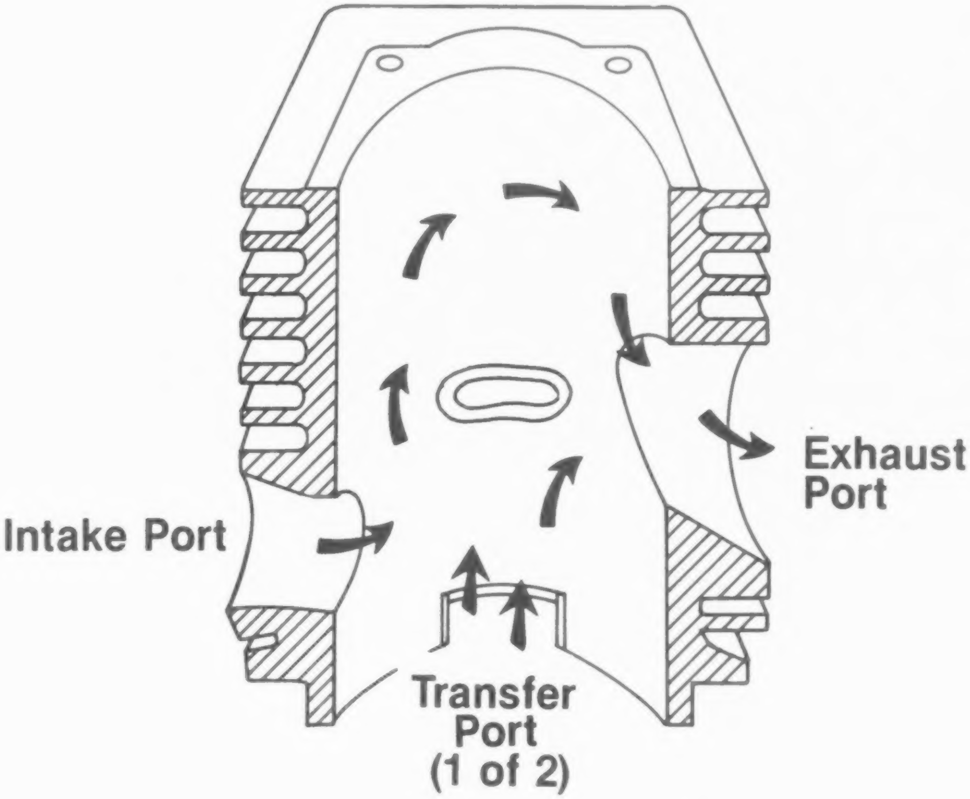
Rotary Valves and Piston Port

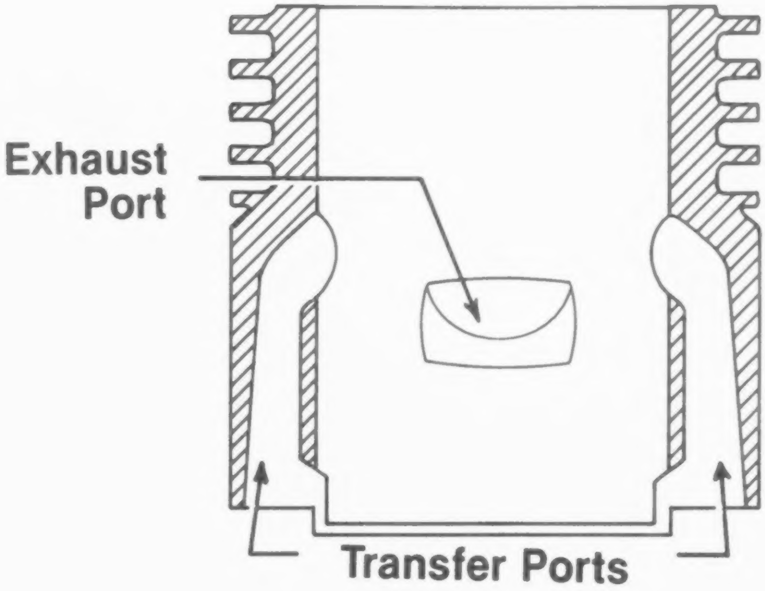

Rotary Valve
Flywheel
Rotary Valve
Fully Open

Firing Charge in Cylinder

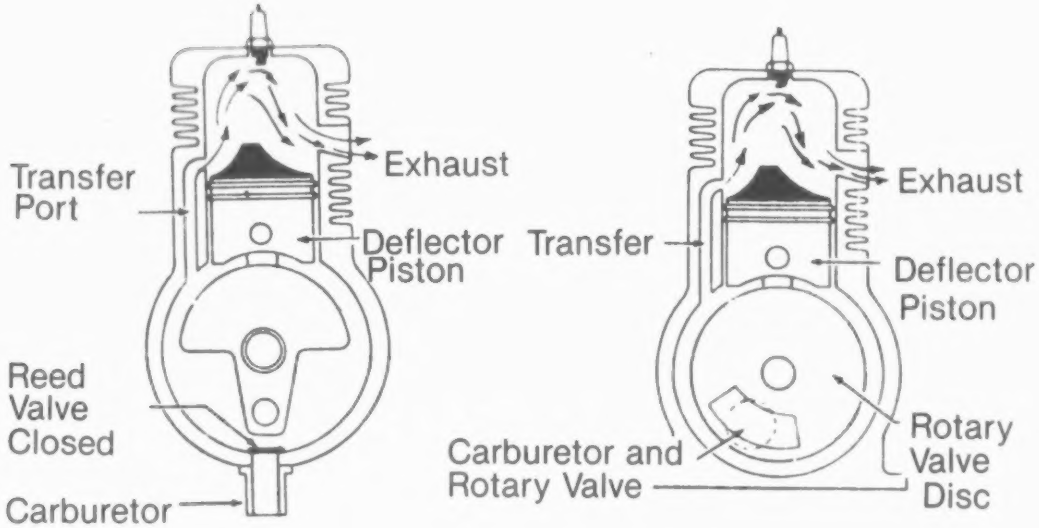

Exhaust Port
Intake Port
Intake and
Compression
Stroke -

Timing Essentials

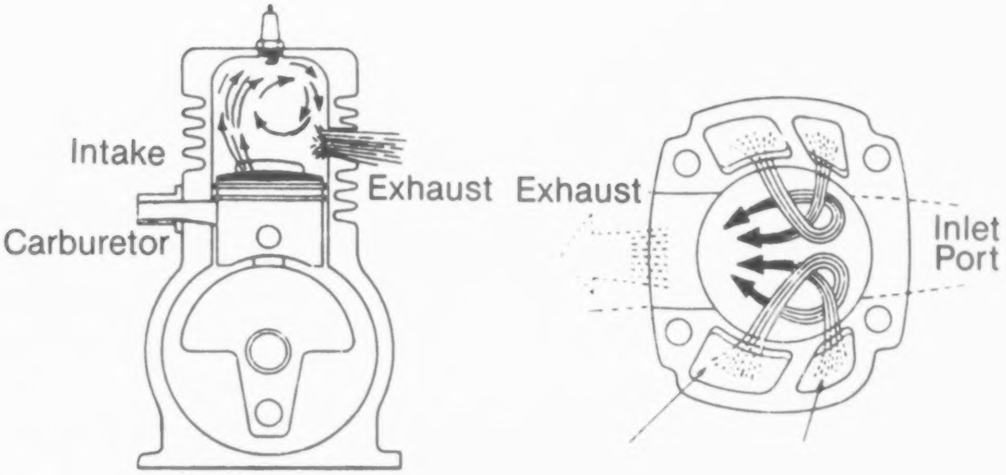

Intake Port
Exhaust Port
Transfer Port (1 of 2)


Exhaust Port
Transfer Ports

Design Variations


Transfer
Port
Exhaust
Deflector
Piston
Reed
Valve
Closed
Carburetor
Exhaust
Transfer
Deflector
Piston
Rotary
Valve
Disc
Carburetor and
Rotary Valve

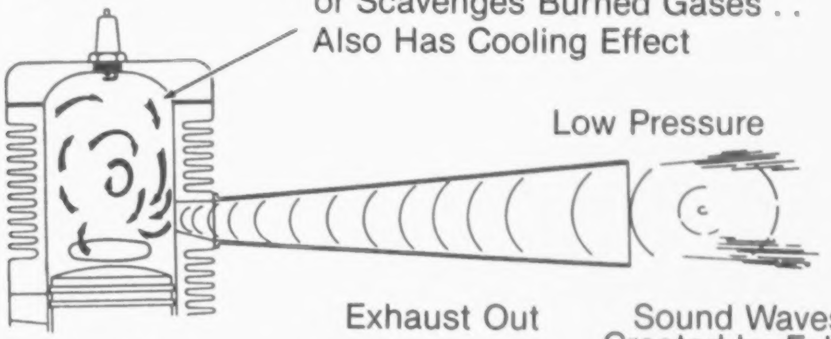
Cross Scavenged


Intake
Carburetor
Exhaust
Exhaust
Inlet
Port

Loop Scavenged

Exhaust System Design

Correct



Higher Pressure Inside Cylinder

Loop Action of Fuel Cleans or Scavenges Burned Gases . . Also Has Cooling Effect

Low Pressure

Exhaust Out

Sound Waves Created by Exhaust

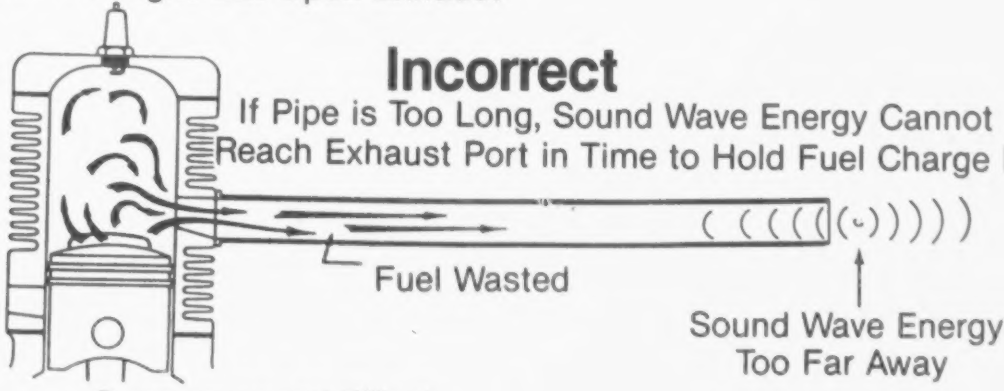
Transfer Port Pulls New Fuel Charge in From Crankcase

Scavenging Effect

Reflected Sound Waves Hold Fuel Charge in Cylinder

Without Back Pressure Fuel Can Go Right Out Open Exhaust

Incorrect



If Pipe is Too Long, Sound Wave Energy Cannot Reach Exhaust Port in Time to Hold Fuel Charge In

Fuel Wasted

Sound Wave Energy Too Far Away

Overscavenged Effect (Pipe Too Long)

Overscavenging From Wrong Length of Exhaust Pipe

PRINCIPLES OF OPERATION — TWO-STROKE CYCLE
UNIT IV-B

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. Pressure built up in the crankcase by the downward movement of the piston

_____b. One way valve made of spring steel which allows the fuel-air mixture to flow in one direction only

_____c. Openings in the cylinder wall which allows the exhaust to escape

_____d. Passage which allows movement of the fuel-air mixture from the crankcase into the combustion chamber

_____e. Flat circular plate with a section of the plate cut away that operates between the carburetor and the crankcase

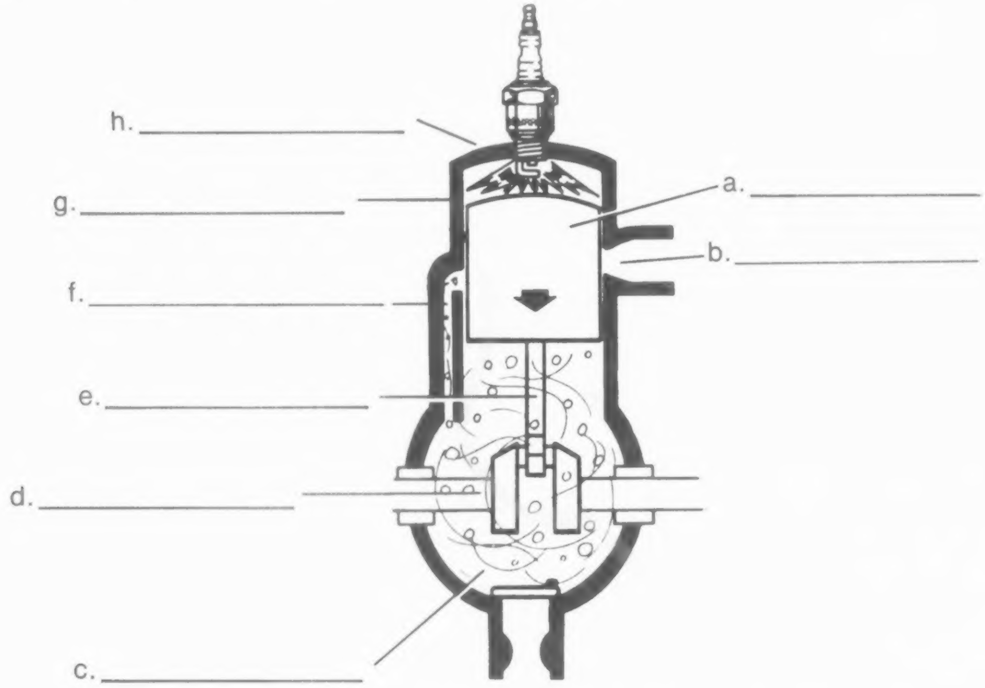
_____f. Exhaust system specially designed to produce maximum horsepower at a specific RPM range

_____g. Negative crankcase pressure created when piston moves upward in cylinder

1. Transfer port
2. Reed valve (leaf valve)
3. Exhaust port
4. Expansion chamber
5. Crankcase pressure
6. Crankcase vacuum
7. Rotary valve

TEST

2. Identify the components of a basic two-stroke cycle engine.



3. Select true statements concerning the operation of a two-stroke cycle engine by placing an "X" in the appropriate blanks.

_____a. Piston moves down cylinder drawing fuel-air mixture into crankcase

_____b. Piston moves down cylinder, pressurizing mixture in crankcase

_____c. Piston moves past transfer port allowing pressurized mixture to move into crankcase

_____d. Piston moves up in cylinder again and draws more fuel-air mixture into crankcase

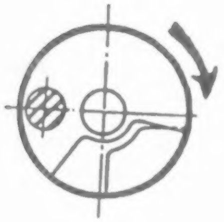
_____e. Spark plug fires compressed mixture

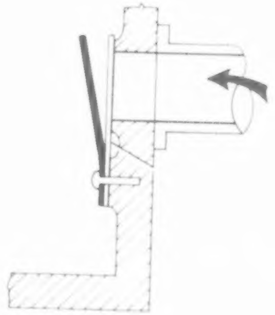
_____f. Combustion moves piston back down cylinder

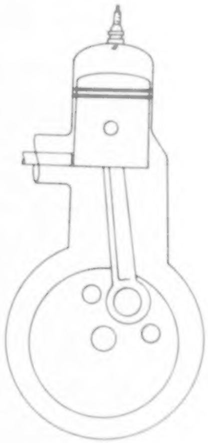
_____g. Piston starts back up cylinder closing transfer port and opening exhaust port

TEST

4. Identify the types of valves that may be used in two-stroke cycle engines.







a. ______________________ b. ______________________ c. ______________________

5. Select the factors which determine timing on a two-stroke cycle engine by placing an "X" in the appropriate blanks.

_____a. Location of transfer port

_____b. Location of cam lobe positions

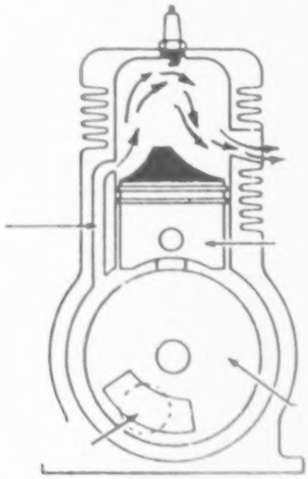
_____c. Location of exhaust valve

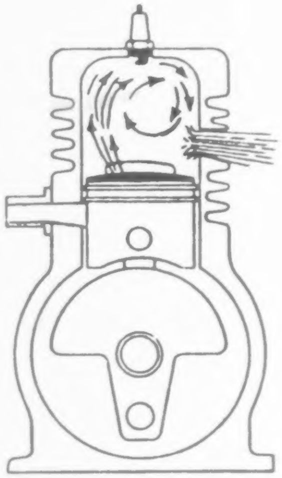
_____d. Location of intake port

_____e. Location of exhaust port

TEST

6. Distinguish between cross-scavenged and loop-scavenged two-stroke cycle engines by writing the name of each in the appropriate blank.





a. ______________________   b. ______________________

7. List three features which make a two-stroke cycle engine preferable for many applications.

   a. ____

   b. ____

   c. ____

8. Complete the following statements concerning the importance of correct exhaust system design on a two-stroke cycle engine by circling the correct words.

   a. Scavenges **(all, partial)** exhaust from combustion chamber

   b. Allows new fuel charge to move into combustion chamber **(rapidly, slowly)**

   c. Sound waves hold fuel charge momentarily while exhaust port is **(open, closed)**

PRINCIPLES OF OPERATION — TWO-STROKE CYCLE
UNIT IV-B

ANSWERS TO TEST

1. a. 5
   b. 2
   c. 3
   d. 1
   e. 7
   f. 4
   g. 6

2. a. Piston
   b. Exhaust port
   c. Crankcase
   d. Crankshaft
   e. Connecting rod
   f. Transfer port
   g. Cylinder
   h. Cylinder head

3. b,d,e,f

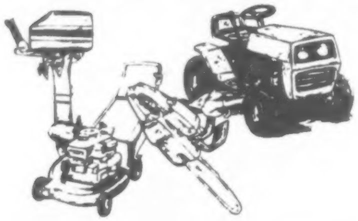
4. a. Rotary
   b. Reed
   c. Piston port

5. a,d,e

6. a. Cross-scavenged
   b. Loop-scavenged

7. Any three of the following:
   a. Simple design
   b. Light weight
   c. Smaller size for equivalent horsepower
   d. Adequate lubrication in any position
   e. Continuous supply of new, clean oil to all moving parts

8. a. All
   b. Rapidly
   c. Open



Basic Electricity
Unit I-C

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify types of electrical circuits, solve problems using Ohm's law, and demonstrate the ability to check electrical circuits using an ohmmeter, ammeter, and voltmeter. Competencies will be demonstrated by correctly performing the procedures outlined in the assignment and job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

1. Match terms related to basic electricity with their correct definitions.
2. Select sources of electricity related to small engine repair.
3. Select parts of a basic circuit.
4. Distinguish between good conductors and insulators of electricity.
5. Distinguish between direct and alternating current.
6. Match basic electrical schematic symbols with their correct names.
7. Match the letter designations used in Ohm's law with their correct terms.
8. Draw Ohm's law in triangle expression.
9. State Ohm's law in letter formula for calculating voltage, current, and resistance.
10. Identify three types of electrical circuits.
11. Select true statements concerning rules for series circuits.

OBJECTIVE SHEET

12. Complete a list of rules for parallel circuits.
13. Select factors affecting resistance in a conductor.
14. Select true statements concerning the relationship between electricity and magnetism.
15. Select factors that determine the magnitude of induced voltage.
16. List three instruments used in checking electrical circuits.
17. Solve problems using Ohm's law formula (Assignment Sheet #1).
18. Identify basic electrical schematic symbols (Assignment Sheet #2).
19. Demonstrate the ability to:
    a. Measure resistance using an ohmmeter (Job Sheet #1).
    b. Check continuity (Job Sheet #2).
    c. Use an ohmmeter to test for defective diodes (Job Sheet #3).
    d. Measure amperage in a circuit (Job Sheet #4).
    e. Check voltage (Job Sheet #5).
    f. Use a digital voltohmmeter (Job Sheet #6).

BASIC ELECTRICITY
UNIT I-C

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with assignment and job sheets prior to the demonstration of the procedures.

H. Integrate the following activities throughout the teaching of this unit:

1. Discuss electron theory to promote a basic understanding of electricity.
2. Prepare a training aid to help teach basic principles of electricity.
3. Demonstrate magnetic lines of force by using iron fillings and a conductor.
4. Demonstrate the construction of a series and a parallel circuit.
5. Provide inductance ammeter for class to check current flow in an operating system such as a garden tractor.

   (NOTE: If your shop does not have an inductance ammeter, check with automotive instructor about borrowing one.)
6. Discuss procedures outlined in the assignment sheets.
7. Demonstrate and discuss procedures outlined in the job sheets.
8. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

SUGGESTED ACTIVITIES

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

   1. TM 1 — Sources of Electricity
   2. TM 2 — Ohm's Law in Triangle Expression
   3. TM 3 — Ohm's Law in Letter Formula
   4. TM 4 — Series Circuit Rules
   5. TM 5 — Parallel Circuit Rules
   6. TM 6 — Magnetism and Field of Force
   7. TM 7 — Electricity and Magnetism Relationship
   8. TM 8 — Measuring Instruments

E. Assignment sheets

   1. Assignment Sheet #1 — Solve Problems Using Ohm's Law
   2. Assignment Sheet #2 — Identify Basic Electrical Schematic Symbols

F. Answers to assignment sheets

G. Job sheets

   1. Job Sheet #1 — Measure Resistance Using an Ohmmeter
   2. Job Sheet #2 — Check Continuity
   3. Job Sheet #3 — Use an Ohmmeter to Test for Defective Diodes
   4. Job Sheet #4 — Measure Amperage in a Circuit
   5. Job Sheet #5 — Check Voltage
   6. Job Sheet #6 — Use a Digital Voltohmmeter

SUGGESTED ACTIVITIES

H. Test

I. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Parady, Harold W., and J. Howard Turner. *Electrical Energy.* Athens, Georgia: American Association for Vocational Instructional Materials, 1976.

B. *Small Engines, Volume 2.* Athens, Georgia: American Association for Vocational Instructional Materials, 1971.

C. *Comprehensive Small Engine Repair.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1977.

BASIC ELECTRICITY
UNIT I-C

INFORMATION SHEET

I. Terms and definitions

A. Ampere — Unit of measure for electrical current

B. Ohm — Standard unit for measuring resistance to flow of an electrical current

C. Resistance — Opposition to current flow in a conductor

D. Voltage (emf) — Electromotive force which causes current to flow in an electrical circuit

E. Current — Flow of electrons through a conductor, measured in amperes

F. Conductor — Substance or body through which an electrical current readily flows

Examples: Copper, aluminum, silver

G. Insulator — Material which does not readily permit current flow

Examples: Rubber, glass, porcelain, air, oil, and plastic

H. Semiconductor — An element with an atomic configuration which makes it neither a good conductor nor insulator

I. Circuit — Continuous, unbroken path along a conductor through which electrical current can flow from a source, through various units and back to the source

J. Capacitor (condenser) — Device which stores an electrical charge

K. Magnetic induction — Inducing voltage in a conductor that moves across a magnetic field

II. **Sources of electricity (Transparency 1)**

A. Chemical

Example: Battery

B. Magnetic

Example: Generator

INFORMATION SHEET

III. **Parts of a basic circuit**

A. Voltage source

Example: Battery

B. Resistor

Example: Light bulb

C. Conductor

Example: Copper wire

IV. **Conductors and insulators of electricity**

A. Conductors

1. Copper

(NOTE: Copper is a good conductor because it has only one electron in outer ring and is comparatively cheaper than other metals which may have similar properties.)

2. Aluminum
3. Steel
4. Lead
5. Mercury

B. Insulators

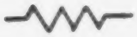
1. Glass
2. Rubber
3. Plastic
4. Wood

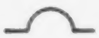
INFORMATION SHEET

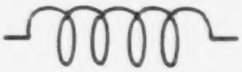
V. **Direct and alternating current**

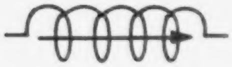
- A. Direct current
  - 1. Supplied by
    - a. Generator
    - b. Battery
      - 1) Dry cell
      - 2) Wet cell
  - 2. Flows in one direction only
  - 3. Abbreviated as DC
- B. Alternating current
  - 1. Supplied by an alternating current generator (alternator)
  - 2. Flows in one direction then reverses and flows in the opposite direction
  - 3. Abbreviated as AC

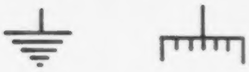
VI. **Basic electrical schematic symbols**

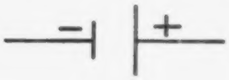
A. Resistance or load 

B. Ohms of resistance 

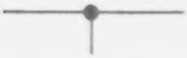
C. Coil 

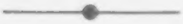
D. Solenoid 

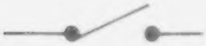
E. Ground 

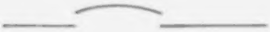
F. Battery 

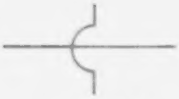
INFORMATION SHEET

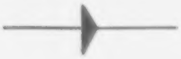
G. Connection


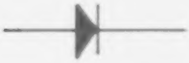
H. Terminal


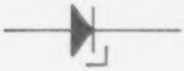
I. Switch (open)


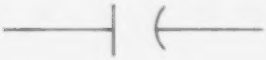
J. Circuit breaker


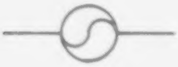
K. Crossover


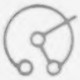
L. Direction of current


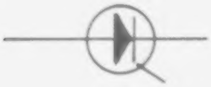
M. Diode (one-way)


N. Zener diode


O. Capacitor


P. Fuse


Q. Rheostat


R. Silicon controlled rectifier (SCR)


VII. **Letters and their terms**

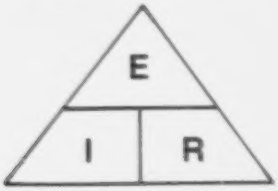
A. E — Electromotive force in volts

B. I — Intensity (current) in amps

C. R — Resistance in ohms

INFORMATION SHEET

VIII. **Ohm's law formula in triangle expression (Transparency 2)**



(NOTE: E.I.R. formula reminder is the phrase "Even I Remember.")

IX. **Ohm's law in letter formula (Transparency 3)**

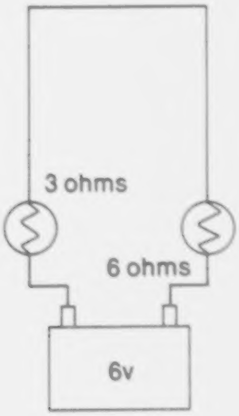
A. E = 1 × R or Volts = Amps × Ohms

B. I = E/R or Amps = Volts ÷ Ohms

C. R = E/I or Ohms = Volts ÷ Amps

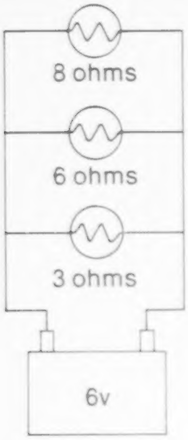
X. **Types of electrical circuits**

A. Series

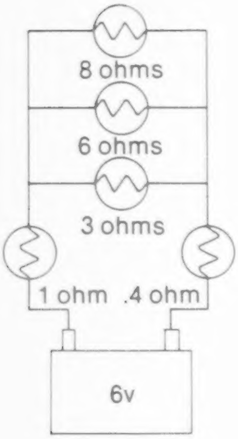


INFORMATION SHEET

B. Parallel



C. Series-parallel



XI. **Rules for series circuits (Transparency 4)**

A. Current through each resistor is the same

B. Voltage drops across each resistor will be different if the resistance values are different

C. Sum of the voltage drops equals the source voltage

XII. **Rules for parallel circuits (Transparency 5)**

A. Voltage across each resistor is the same

B. Current through each resistor will be different if the resistance values are different

C. Sum of the separate currents equals the total circuit current

INFORMATION SHEET

XIII. **Factors affecting resistance in a conductor**

A. Length

B. Diameter

C. Temperature

D. Composition

XIV. **Relationship between electricity and magnetism (Transparency 6 & 7)**

A. Current passed through a wire (conductor) creates a magnetic field around the wire

B. Magnetic lines have direction and change direction when the current flow changes from one direction to another

(NOTE: The Right Hand Rule for a straight conductor can be used to find the direction of the lines of force around the wire. To apply the rule, grasp the wire with the thumb extended in the direction of conventional current flow (positive to negative); the fingers will then point in the direction in which the lines of force surround the conductor. These lines of force are always at right angles to the conductor.)

C. Conductor moving across a magnetic field will have a voltage induced in it

D. Voltage polarity and the current flow direction are determined by the direction of wire movement and direction of the lines of force

(NOTE: The conductor can move or the magnetic field can move.)

E. Ways to induce voltage by magnetic induction

1. Generated voltage by relative motion

   Examples: Generators and alternators

2. Self-induction voltage created by a change of current in the conductor

   Example: Primary of ignition coils

3. Mutual-induction which occurs when changing current in one coil induces voltage in a second coil

   Example: Two windings of ignition coils

INFORMATION SHEET

F. Two conductors on an armature, carrying current in opposite directions, create a strong and weak field on opposite sides causing conductors to move apart or armature to rotate

(NOTE: The downward movement or rotation is caused by current flowing in the conductor. This is the principle by which a cranking motor operates.)

XV. **Factors that determine the magnitude of induced voltage**

A. Strength of the magnetic field

B. Speed at which lines of force are cutting across the conductor

C. Number of conductors that are cutting across the lines of force

XVI. **Instruments used in checking electrical circuits (Transparency 8)**

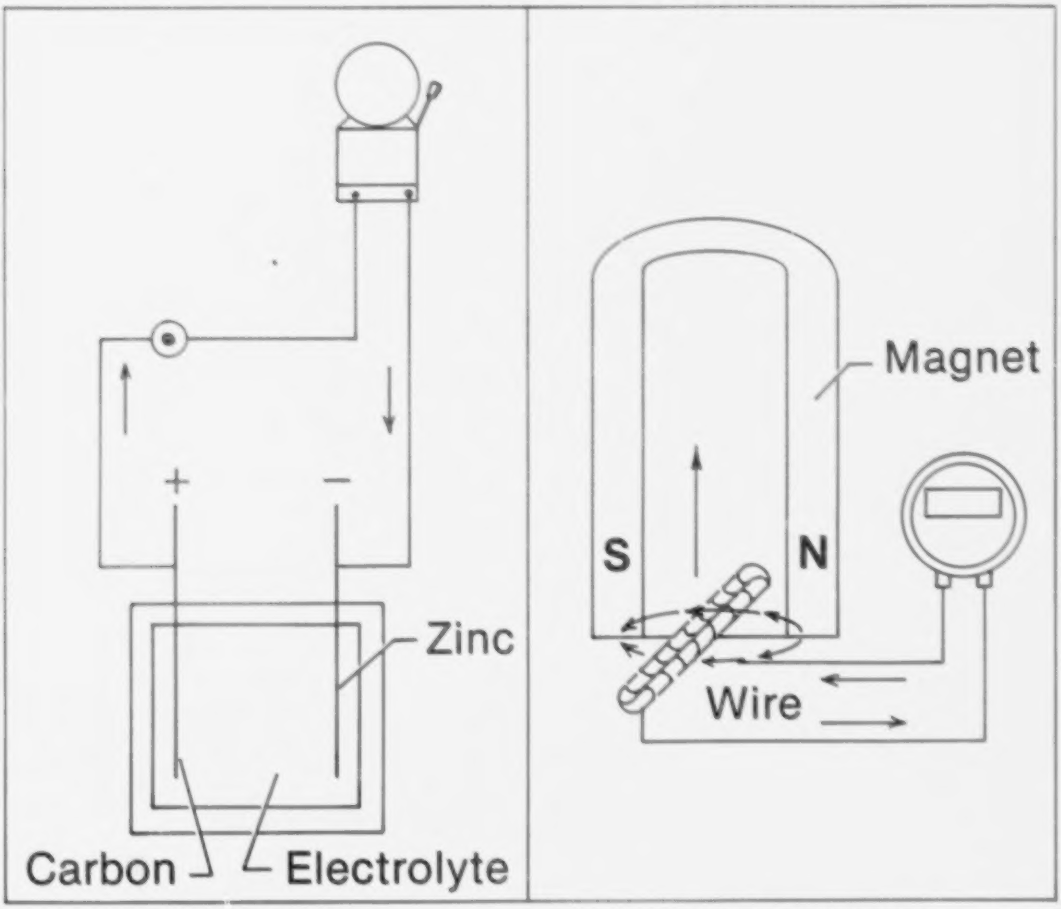
A. Ammeter

B. Voltmeter

C. Ohmmeter

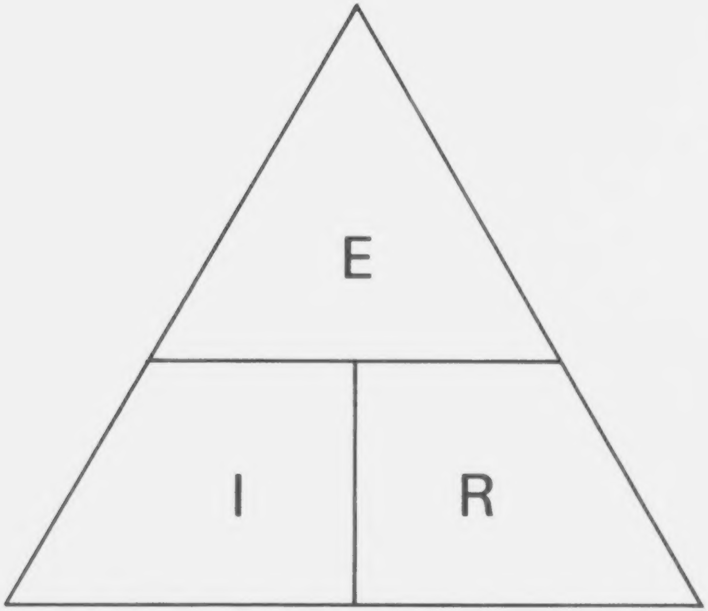
(NOTE: Modern testers often combine the voltmeter, ammeter, and ohmmeter in one test unit, such as a battery-starter tester.)

Sources of Electricity


+
−
Zinc
Carbon
Electrolyte
Magnet
S
N
Wire

CHEMICAL **MAGNETIC**

Ohm's Law in Triangle Expression



NOTE: Solve for Volts, Amps,
or Resistance by
Covering the Unknown

Example: Cover E, then E = I × R
Cover I, then I = E ÷ R
Cover R, then R = E ÷ I

E = Volts I = Amps R = Resistance

Ohm's Law in Letter Formula

Electromotive Force = Current × Resistance

$E = IR$ Volts = Amperes × Ohms

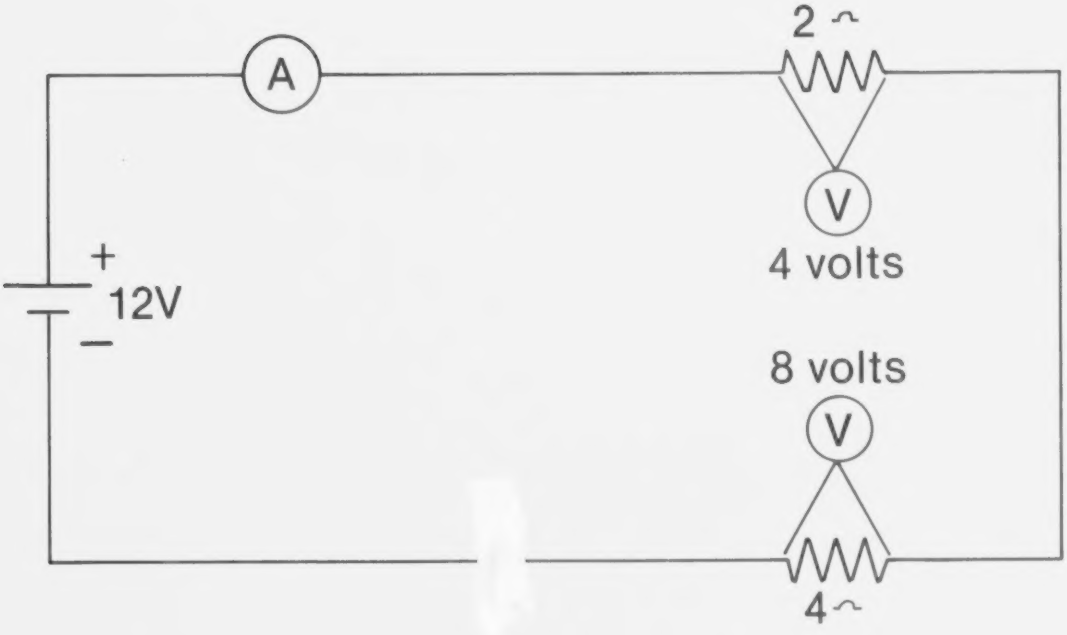
$$\text{Current} = \frac{\text{Electromotive Force}}{\text{Resistance}}$$

$$I = \frac{E}{R} \quad \text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

$$\text{Resistance} = \frac{\text{Electromotive Force}}{\text{Current}}$$

$$R = \frac{E}{I} \quad \text{Ohms} = \frac{\text{Volts}}{\text{Amperes}}$$

Series Circuit Rules



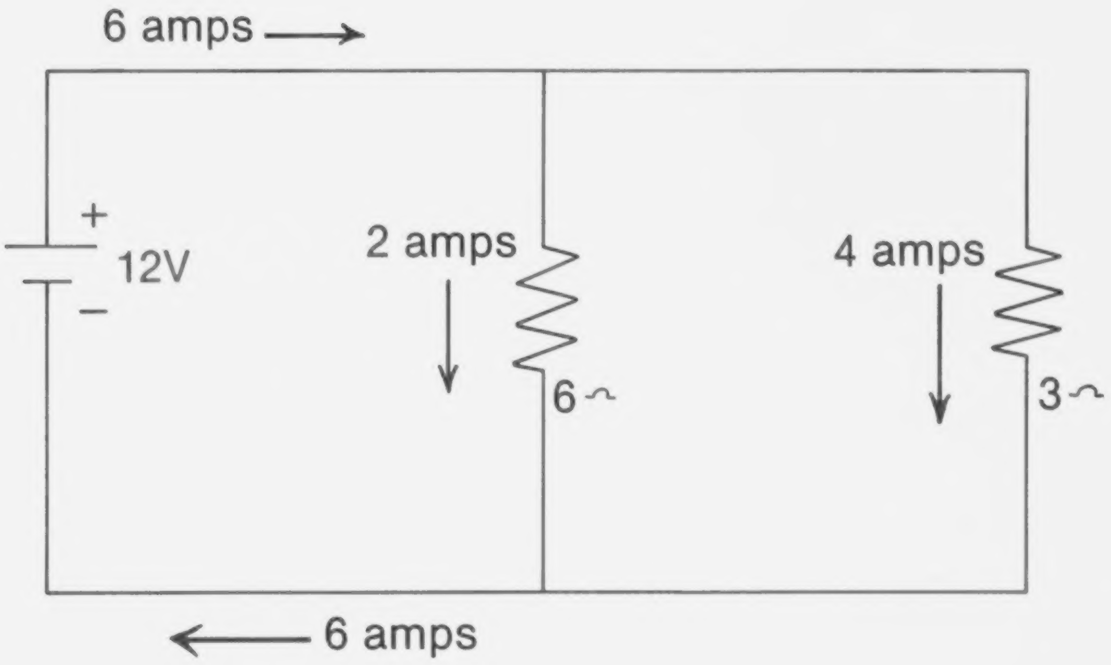
2 Ω
A
V
4 volts
+
12V
−
8 volts
V
4 Ω

A. I = E/R
   I = 12/6 = 2 amp

B. E = IR
   E = 2 × 2 = 4 volts
   E = 2 × 4 = 8 volts

C. 4 + 8 = 12 volts

Parallel Circuit Rules

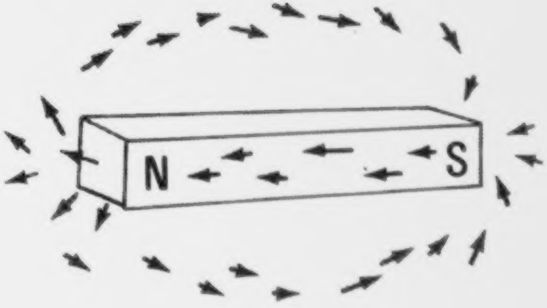

6 amps
+
12V
−
2 amps
6 ᘯ
4 amps
3 ᘯ
6 amps

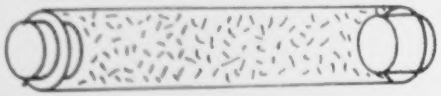
A. Battery voltage across
each resistor 12 volts

B. I = E/R 12/6 = 2 ampere
I = E/R 12/3 = 4 ampere

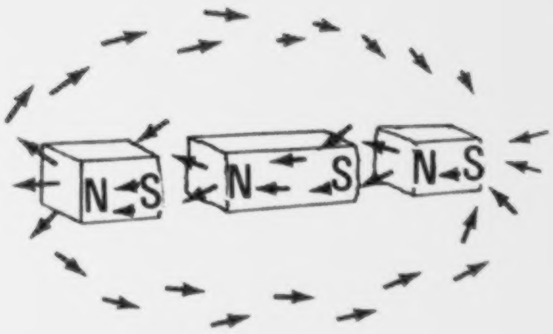
C. I = 6 amps
R = E/I 12/6 = 2 ohms

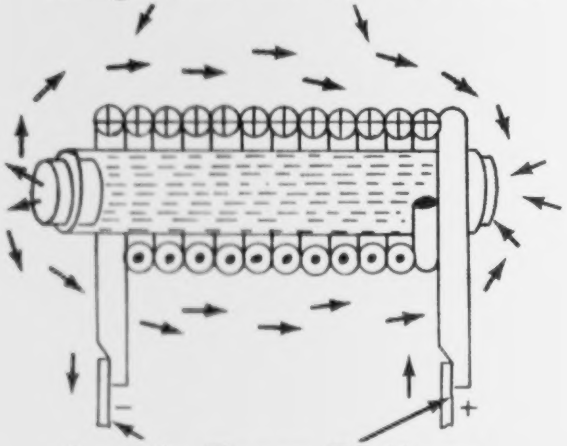
Magnetism and Field of Force





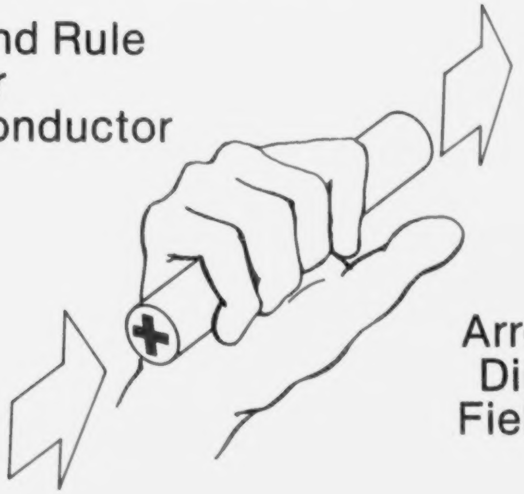
Unmagnetized Iron Filings




Magnetic Lines of Force
−
+
Leads From Battery

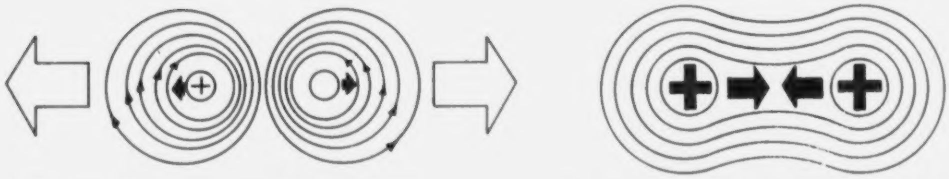
Electricity and Magnetism Relationship

Right Hand Rule
for
Straight Conductor



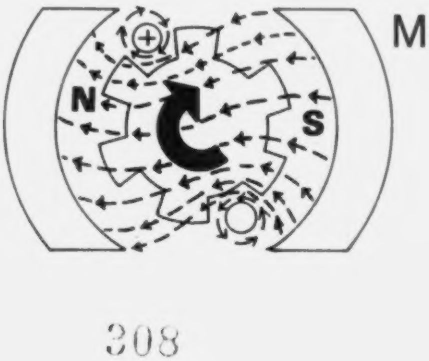
Arrows Show
Direction of
Field of Force

Strong Field Between Conductors



Conductors Tend To
Move Apart

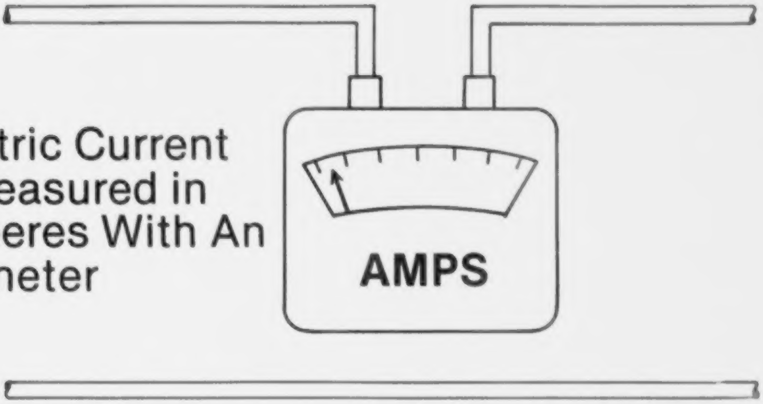
Conductors Tend To
Move Together



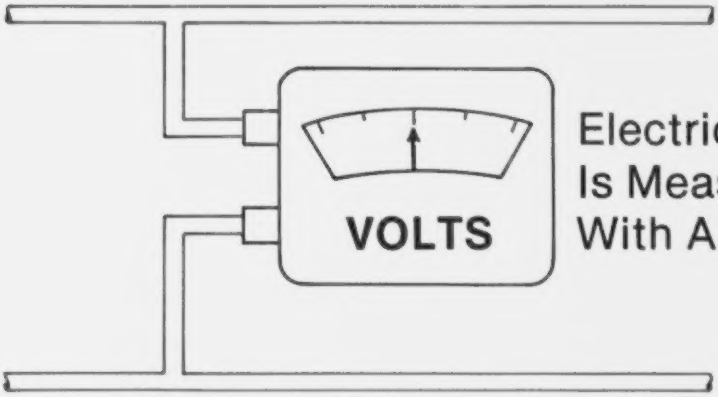
Motor Principle

SE-29-C

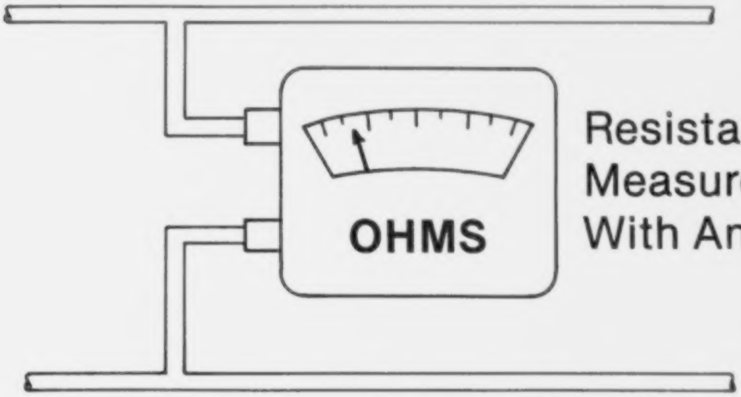
Measuring Instruments



Electric Current Is Measured in Amperes With An Ammeter



Electric "Pressure" Is Measured In Volts With A Voltmeter



Resistance Is Measured In OHMS With An Ohmmeter

BASIC ELECTRICITY
UNIT I-C

ASSIGNMENT SHEET #1 — SOLVE PROBLEMS USING OHM'S LAW

Directions: Read the problems and use the triangle expression of Ohm's law to solve for the unknown value in each problem.

Example: Cover the unknown in the triangle and solve

(NOTE: E = Voltage; I = Amperes; R = Resistance.)

Show your work on each problem. Turn in to instructor after completion.

1. A current of 4 amperes is needed to operate a certain light bulb having a resistance of 3 ohms. What voltage is required?

2. Through how many ohms of resistance does 12 volts force a current of 12 amperes?

3. An electric horn requires 12 volts. The resistance is 20 ohms. What current does the horn take?

(NOTE: The electrical energy consumed in any resistance appears as heat. There is a definite relation between the power consumed and the heat produced. This is in accordance with the principle that energy cannot be destroyed.)

ASSIGNMENT SHEET #1

4. A light bulb having a resistance of 6 ohms uses 2 amperes of current while in operation. What is the voltage applied to the circuit?

5. A horn connected to a 12 volt battery uses 2 amperes of current for its operation. What is the resistance of the horn?

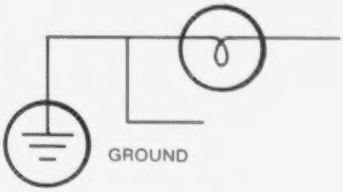
BASIC ELECTRICITY
UNIT I-C

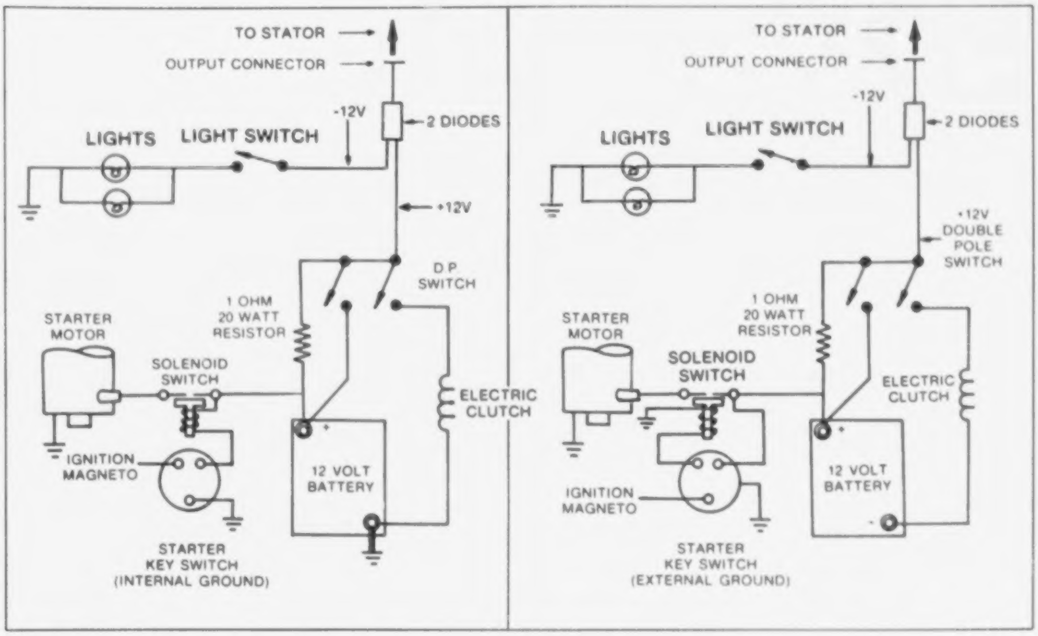
ASSIGNMENT SHEET #2 — IDENTIFY BASIC ELECTRICAL SCHEMATIC SYMBOLS

Directions: Circle and identify the basic electrical schematic symbols which appear on the wiring diagram below.

(NOTE: Red or blue ink is suggested to contrast with diagram.)

Example:




TO STATOR
OUTPUT CONNECTOR
-12V
2 DIODES
LIGHTS
LIGHT SWITCH
+12V
D P
SWITCH
1 OHM
20 WATT
RESISTOR
STARTER
MOTOR
SOLENOID
SWITCH
ELECTRIC
CLUTCH
IGNITION
MAGNETO
12 VOLT
BATTERY
STARTER
KEY SWITCH
(INTERNAL GROUND)
TO STATOR
OUTPUT CONNECTOR
-12V
2 DIODES
LIGHTS
LIGHT SWITCH
+12V
DOUBLE
POLE
SWITCH
1 OHM
20 WATT
RESISTOR
STARTER
MOTOR
SOLENOID
SWITCH
ELECTRIC
CLUTCH
IGNITION
MAGNETO
12 VOLT
BATTERY
STARTER
KEY SWITCH
(EXTERNAL GROUND)

BASIC ELECTRICITY
UNIT I-C

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. Covering up the E shows the formula for this problem to be I × R. Therefore, E = IR = 4 × 3 = 12 volts.
2. Covering up the R shows that R = E/I which equals 12/12 = 1 ohm.
3. Covering up the I shows that I = E/R. Therefore, 12/20 = .6 amperes.
4. E = I × R. Therefore, 6 × 2 = 12 volts.
5. R = E/I. Therefore, 12/2 = 6 ohms.

Assignment Sheet #2 — Evaluated according to standards identified by the instructor

(NOTE: If instructor prefers, students may perform a self-check by reviewing symbols found in objective VI of this unit.)

BASIC ELECTRICITY
UNIT I-C

JOB SHEET #1 — MEASURE RESISTANCE USING AN OHMMETER

A. Equipment and materials needed

1. Ohmmeter
2. Three various lengths of wires at same gauge
3. Three of same length of wire at various gauges

B. Procedure

1. Turn ohmmeter on
2. Connect terminal leads of ohmmeter together and observe meter reading to check operation of meter
3. Attach negative lead to one end of wire
4. Attach positive lead to other end of wire
5. Read and record resistance in space provided below
6. Repeat steps 3-5 for other wires
7. Clean work area

Various Lengths of Wire at Same Gauge

____________	____________	____________
Wire #1	Wire #2	Wire #3

Same Lengths of Wire at Various Gauges

____________	____________	____________
Wire #1	Wire #2	Wire #3

BASIC ELECTRICITY
UNIT I-C

JOB SHEET #2 — CHECK CONTINUITY

A. Equipment and materials needed

1. Battery
2. Ohmmeter
3. Appropriate service manual
4. Safety glasses

B. Procedure

(CAUTION: Remove all jewelry before working on electrical circuits and follow all shop safety procedures.)

1. Disconnect battery ground cable from battery terminal

   (CAUTION: Continuity light will be damaged if ground cable is not disconnected.)

2. Connect ohmmeter positive (+) lead to hot lead of the circuit
3. Connect ohmmeter negative (-) lead to ground
4. If the bulb lights or if the ohmmeter scale indicates minor resistance, the circuit is okay

   (NOTE: Switches and grounds are checked in the same manner.)

BASIC ELECTRICITY
UNIT I-C

JOB SHEET #3 — USE AN OHMMETER TO TEST FOR DEFECTIVE DIODES

A. Equipment and materials needed

1. Ohmmeter with test leads
2. Assortment of diodes furnished by instructor
3. Safety glasses

B. Procedure

(NOTE: Recall that diodes pass current easily in one direction but not in the opposite direction. Use this information to determine which diodes may be defective.)

1. Connect ohmmeter across diodes, one at a time, and switch leads to determine whether there is a difference in conductivity
2. Separate diodes by placing defective ones on workbench in a group to the left

   (NOTE: Discuss your results with your instructor.)
3. Disconnect ohmmeter
4. Clean work area; put away equipment and materials

BASIC ELECTRICITY
UNIT I-C

JOB SHEET #4 — MEASURE AMPERAGE IN A CIRCUIT

A. Equipment and materials needed

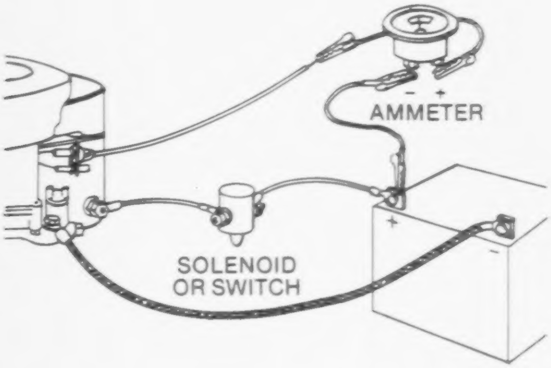
1. Ammeter
2. Test leads
3. Operating system
4. Safety glasses

B. Procedure

(CAUTION: Remove all jewelry before working on any electrical circuit and follow all shop safety procedures.)

1. Disconnect charging lead from battery circuit
2. Attach ammeter in series with charging lead (Figure 1)

FIGURE 1



3. Start engine
4. Read ammeter and record charge rate in space provided ______________

(NOTE: The charge rate is dependent on the battery.)

5. Turn off engine
6. Disconnect ammeter from charging lead circuit
7. Reconnect charging lead to battery circuit

BASIC ELECTRICITY
UNIT I-C

JOB SHEET #5 — CHECK VOLTAGE

A. Equipment and materials needed

1. Battery
2. Voltmeter
3. Appropriate service manual
4. Safety glasses

B. Procedure

(CAUTION: Remove all jewelry before working on any electrical circuit and follow all shop safety procedures.)

1. Connect negative lead from voltmeter to negative (-) battery terminal
2. Connect positive lead from voltmeter to positive (+) battery terminal

   (NOTE: The positive (+) battery terminal is larger in diameter than the negative (-) terminal.)

3. Read voltmeter scale to determine if battery contains normal rated voltage according to manufacturers' specifications
4. If battery is on full charge, continue with other electrical tests as necessary
5. If battery voltage is below normal rating, recharge before performing other electrical tests
6. Clean work area; put away equipment and materials

BASIC ELECTRICITY
UNIT I-C

JOB SHEET #6 — USE A DIGITAL VOLTOHMMETER

A. Equipment and materials needed

1. Digital voltohmmeter and instruction booklet

   (NOTE: Use only meters with a 10-megohm impedance for testing computerized components.)

2. Circuit containing less than 1 volt
3. Circuit containing variable resistance
4. Appropriate service manual
5. Safety glasses

B. Procedure

1. Test accuracy of voltohmmeter
   a. Place meter selectors in TEST position
   b. Verify reading on meter with specified reading in instruction booklet
   c. If meter is inaccurate, replace with another and repeat test
2. Test circuit containing normal battery voltage
   a. Place FUNCTION switch at DC VOLTS indicator
   b. Check range of circuit in service manual, and place RANGE switch in proper position

      EXAMPLE: Range 1 = 1 to 10 volts
      Range 10 = 10 to 100 volts
      Range 100 = 100 to 1000 volts
      Range 1000 = 1000 to 100,000 volts

      (NOTE: If meter is equipped with AUTO position, it will select the proper range automatically. If meter is not equipped with AUTO position, prevent damage to meter by placing range selector on highest scale and reducing to lower scales until satisfaction reading is obtained.)

JOB SHEET #6

c. Connect red lead of meter to source of power to be tested; connect black lead to suitable ground; turn on current

d. Observe reading, and compare to manufacturer's specifications

e. Turn off current, and disconnect meter leads

3. Test circuit of less than 1 volt

a. Place FUNCTION switch at MILLIVOLTS indicator

b. Check range of circuit in service manual, and place RANGE switch in proper position

EXAMPLE: Range 1 = 0 to 10 millivolts
Range 10 = 10 to 100 millivolts
Range 100 = 100 to 1000 millivolts

(NOTE: If meter is equipped with AUTO position, it will select proper range automatically. If meter is not equipped with AUTO position, prevent damage to meter by placing range selector on highest scale and reducing to lower scales until satisfactory reading is obtained.)

c. Connect red lead of meter to source of power to be tested; connect black lead to suitable ground; turn on current

d. Observe reading, and compare to manufacturer's specifications

e. Turn off current, and disconnect meter leads

4. Test resistance in a circuit or component

a. Turn off current to circuit or component

b. Place FUNCTION switch at proper ohms indicator

(NOTE: Meter indicators vary; therefore, the indicator may designate OHMS, KILOHMS, or MEGOHMS.)

c. Check range of circuit or component in service manual, and place RANGE switch in proper position

EXAMPLES: Function switch in OHMS position:

Range 1 = 0 to 10 ohms
Range 10 = 10 to 100 ohms
Range 100 = 100 to 1000 ohms
Range 1000 = 1000 to 10,000 ohms

JOB SHEET #6

Function switch in KILOHMS position:

Range 1 = 1000 to 10,000 ohms
Range 10 = 10,000 to 100,000 ohms
Range 100 = 100,000 to 1,000,000 ohms

Function switch in MEGOHMS position:

Range 1 = 1 to 10 megohms
Range 10 = 10 to 100 megohms
Range 100 = 100 to 1000 megohms

(NOTE: If meter is equipped with AUTO position, it will select the proper range automatically. If meter is not equipped with AUTO position, prevent damage to meter by placing selector on highest scale and reducing to lower scales until satisfactory reading is obtained.)

d. Connect either red or black lead of meter to one side of component to be tested; connect other lead to opposite side of component; read resistance value

e. Observe reading, and compare to manufacturer's specifications

f. Disconnect meter leads

5. Deenergize voltohmmeter

6. Clean work area; put away tools and equipment

BASIC ELECTRICITY
UNIT I-C

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. Unit of measure for electrical current

_____b. Device which stores an electrical charge

_____c. Continuous, unbroken path along a conductor through which electrical current can flow from a source, through various units and back to the source

_____d. Substance or body through which an electrical current readily flows

_____e. Flow of electrons through a conductor, measured in amperes

_____f. Material which does not readily permit current flow

_____g. Standard unit for measuring resistance to flow of an electrical current

_____h. Opposition to current flow in a conductor

_____i. Inducing voltage in a conductor that moves across a magnetic field

_____j. An element with an atomic configuration which makes it neither a good conductor nor insulator

_____k. Electromotive force which causes current to flow in an electrical circuit

1. Voltage (emf)
2. Magnetic induction
3. Ohm
4. Conductor
5. Capacitor (condenser)
6. Ampere
7. Circuit
8. Current
9. Insulator
10. Resistance
11. Semiconductor

2. Select the sources of electricity related to small engine repair by placing an "X" in the appropriate blanks.

_____a. Pressure

_____b. Magnetic

_____c. Chemical

TEST

3. Select the parts of a basic circuit by placing an "X" in the appropriate blanks.

_____a. Conductor

_____b. Insulator

_____c. Magnet

_____d. Voltage source

_____e. Resistor

4. Distinguish between good conductors and insulators of electricity by placing a "C" in front of the items that are good conductors and an "I" in front of the items that are insulators.

_____a. Mercury

_____b. Lead

_____c. Rubber

_____d. Glass

_____e. Wood

_____f. Steel

_____g. Plastic

_____h. Copper

_____i. Aluminum

5. Distinguish between direct and alternating current by placing a "D" in front of characteristics of a direct current and an "A" in front of characteristics of an alternating current.

_____a. Flows in one direction only

_____b. Supplied by an alternating current generator

_____c. Supplied by generator and battery

_____d. Abbreviated as DC

_____e. Flows in one direction then reverses and flows in the opposite direction

_____f. Abbreviated as AC

TEST

6. Match the basic electrical schematic symbols on the right to the correct names.

_____a. Solenoid

_____b. Battery

_____c. Terminal

_____d. Circuit breaker

_____e. Resistance or load

_____f. Coil

_____g. Ohms of resistance

_____h. Ground

_____i. Connection

_____j. Switch (open)

_____k. Crossover

_____l. Fuse

_____m. Diode (one-way)

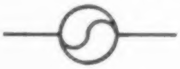
_____n. Zener diode

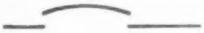
_____o. Capacitor

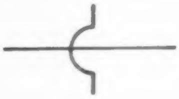
_____p. Direction of current

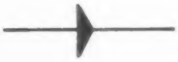
_____q. Silicon controlled rectifier

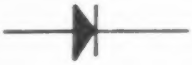
_____r. Rheostat

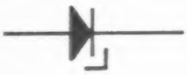
1. 

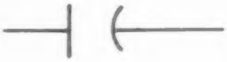
2. 

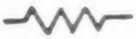
3. 

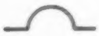
4. 

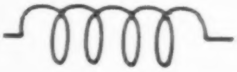
5. 

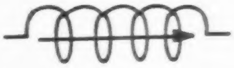
6. 

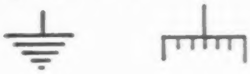
7. 

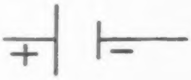
8. 

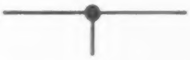
9. 

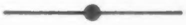
10. 

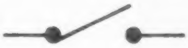
11. 

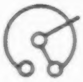
12. 

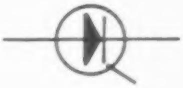
13. 

14. 

15. 

16. 

17. 

18. 

7. Match the letter designations used in Ohm's law on the right with their correct terms.

_____a. Electromotive force in volts

_____b. Intensity in amps

_____c. Resistance in ohms

1. I
2. R
3. E

TEST

8. Draw Ohm's law formula in triangle expression.

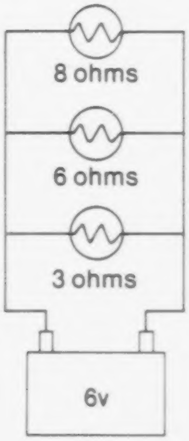
9. State Ohm's law in letter formula for calculating voltage, current, and resistance.

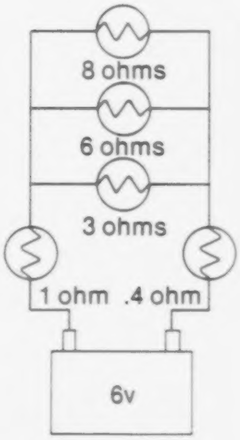
   A. E =

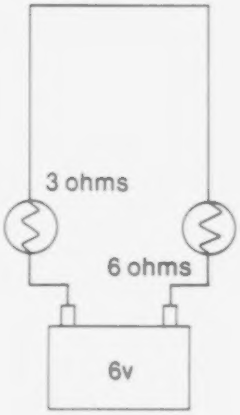
   B. I =

   C. R =

10. Identify the following types of electrical circuits.


8 ohms
6 ohms
3 ohms
6v


8 ohms
6 ohms
3 ohms
1 ohm
.4 ohm
6v


3 ohms
6 ohms
6v

a. ____________________ b. ____________________ c. ____________________

TEST

11. Select true statements concerning rules for series circuits by placing an "X" in the appropriate blanks.

_____a. Current through each resistor is the same

_____b. Voltage drops across each resistor will be different if the resistance values are different

_____c. Sum of the voltage drops equals the source voltage

12. Complete the following list of rules for parallel circuits by correctly filling in the blanks.

a. Voltage across each resistor is _______________.

b. _______________ through each resistor will be different if the resistance values are different

c. Sum of the separate currents equals the total _______________.

13. Select the factors affecting resistance in a conductor by placing an "X" in the appropriate blanks.

_____a. Length

_____b. Altitude

_____c. Viscosity

_____d. Diameter

_____e. Composition

_____f. Temperature

14. Select true statements concerning the relationship between electricity and magnetism by placing an "X" in the appropriate blanks.

_____a. Current passed through a wire (conductor) creates a magnetic field around the wire

_____b. Magnetic lines have direction and change direction when the current flow changes from one direction to another

_____c. Conductor moving across a magnetic field will have a voltage induced in it

_____d. Voltage polarity and the current flow direction are determined by the direction of wire movement and direction of the lines of force

_____e. Mutual induction is one way to induce voltage by magnetic induction and occurs when changing current in one coil induces voltage in the alternator

_____f. Two conductors on an armature, carrying current in opposite directions, create a strong and weak field on opposite sides causing conductors to move apart or armature to rotate

TEST

15. Select factors that determine the magnitude of induced voltage by placing an "X" in the appropriate blanks.

    _____a. Number of conductors that are cutting across the lines of force

    _____b. Strength of the magnetic field

    _____c. Atmospheric pressure

    _____d. Speed at which lines of force are cutting across the conductor

16. List three instruments used in checking electrical circuits.

    a. ______________________________

    b. ______________________________

    c. ______________________________

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

17. Solve problems using Ohm's law formula (Assignment Sheet #1).

18. Identify basic electrical schematic symbols (Assignment Sheet #2).

19. Demonstrate the ability to:

    a. Measure resistance using an ohmmeter (Job Sheet #1).

    b. Check continuity (Job Sheet #2).

    c. Use an ohmmeter to test for defective diodes (Job Sheet #3).

    d. Measure amperage in a circuit (Job Sheet #4).

    e. Check voltage (Job Sheet #5).

    f. Use a digital voltohmmeter (Job Sheet #6).

BASIC ELECTRICITY
UNIT I-C

ANSWERS TO TEST

1.	a.	6	g.	3
	b.	5	h.	10
	c.	7	i.	2
	d.	4	j.	11
	e.	8	k.	1
	f.	9		

2. b,c

3. a,d,e

4.	a.	C	f.	C
	b.	C	g.	I
	c.	I	h.	C
	d.	I	i.	C
	e.	I		

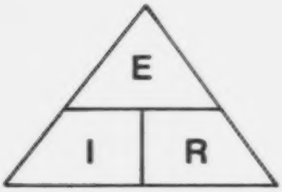
5.	a.	D
	b.	A
	c.	D
	d.	D
	e.	A
	f.	A

6.	a.	11	h.	12	o.	7
	b.	13	i.	14	p.	4
	c.	15	j.	16	q.	17
	d.	2	k.	3	r.	18
	e.	8	l.	1		
	f.	10	m.	5		
	g.	9	n.	6		

7.	a.	3
	b.	1
	c.	2

ANSWERS TO TEST

8.



9. a. $E = I \times R$ or Volts = Amps × Ohms
   b. $I = E/R$ or Amps = Volts ÷ Ohms
   c. $R = E/I$ or Ohms = Volts ÷ Amps

10. a. Series
    b. Parallel
    c. Series-parallel

11. a,b,c

12. a. The same
    b. Current
    c. Circuit current

13. a,d,e,f

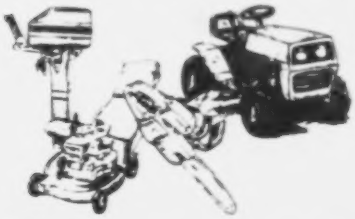
14. a,b,c,d,f

15. a,b,d

16. a. Ammeter
    b. Voltmeter
    c. Ohmmeter

17-18. Evaluated according to the satisfaction of the instructor

19. Performance skills evaluated according to the standards identified by the instructor



Ignition Systems
Unit II-C

After completion of this unit, the student should be able to test the coil, condenser, armature, and flywheel magnets and remove and replace contact points and condenser. The student should also be able to test and adjust a solid state ignition system and remove and replace spark plugs. Competencies will be demonstrated by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

1. State the purpose of the ignition system.
2. Match the types of ignition systems with their correct descriptions.
3. Distinguish between the components of a primary and secondary battery ignition circuit.
4. Identify the components of a magneto ignition system.
5. Identify the components of a solid state ignition system.
6. Identify the components of a breakerless ignition system.
7. Match the components of the ignition system with their correct purposes.
8. Distinguish between the operational steps of the ignition systems.
9. Demonstrate the ability to:
    a. Remove, service, and replace spark plugs (Job Sheet #1).
    b. Remove and replace contact points and condenser (Job Sheet #2).
    c. Test the coil, condenser, armature, and flywheel magnets (Job Sheet #3).

OBJECTIVE SHEET

d. Test and adjust a solid state ignition system (Job Sheet #4).

e. Perform a coil power test (Job Sheet #5).

f. Check ignition timing using a dial indicator (Job Sheet #6).

g. Test condenser for leakage or short (Job Sheet #7).

IGNITION SYSTEMS
UNIT II-C

SUGGESTED ACTIVITIES

A. Obtain additional information and/or invite resource people to class to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets prior to the demonstration of the procedures.

H. Integrate the following activities throughout the teaching of this unit:

1. Show examples of the different types of ignition systems.
2. Show primary and secondary windings of a coil.
3. Obtain a cutaway diagram of a spark plug.
4. Prepare a test board with coils and condensers for student use.
5. Cut a coil and condenser to show makeup.
6. Demonstrate and discuss the procedures outlined in the job sheets.
7. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

SUGGESTED ACTIVITIES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

    1. TM 1 — Primary Circuit
    2. TM 2 — Secondary Circuit
    3. TM 3 — Magneto Ignition System
    4. TM 4 — Solid State Ignition System
    5. TM 5 — Breakerless Ignition System
    6. TM 6 — Principles of a Magneto
    7. TM 7 — Principles of a Magneto (Continued)
    8. TM 8 — Principles of a Magneto (Continued)

E. Job sheets

    1. Job Sheet #1 — Remove, Service, and Replace Spark Plugs
    2. Job Sheet #2 — Remove and Replace Contact Points and Condenser
    3. Job Sheet #3 — Test the Coil, Condenser, Armature, and Flywheel Magnets
    4. Job Sheet #4 — Test and Adjust a Solid State Ignition System
    5. Job Sheet #5 — Perform a Coil Power Test
    6. Job Sheet #6 — Check Ignition Timing Using a Dial Indicator
    7. Job Sheet #7 — Test Condenser For Leakage or Short

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Roth, Alfred C. *Small Gas Engines.* South Holland, Illinois: Goodheart-Willcox Co., 1975.

B. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

IGNITION SYSTEMS
UNIT II-C

INFORMATION SHEET

I. **Purpose of the ignition system** — Produces high voltage current to ignite the fuel-air mixture in the engine cylinder

II. **Types of ignition systems**

  A. Battery ignition system — Uses battery to supply source of current for the primary ignition circuit

  B. Magneto ignition system — Produces current by magnetic induction for the primary ignition circuit without any outside source of electricity

  C. Solid state ignition system — Uses semiconductors in place of one or more standard ignition components

  D. Breakerless ignition system — Uses electronic parts in place of mechanically operated ignition points

III. **Battery ignition systems circuit components** (Transparencies 1 and 2)

  A. Primary circuit (low voltage)

    1. Battery
    2. Ignition switch
    3. Resistance unit (resistor)
    4. Primary winding
    5. Contact points
    6. Condenser
    7. Low voltage wire

  B. Secondary circuit (high voltage)

    1. Secondary winding
    2. Distributor cap
    3. Rotor
    4. Spark plug
    5. High voltage wire

INFORMATION SHEET

IV. **Components of a magneto ignition system** (Transparency 3)

- A. Primary system (low voltage)
    - 1. Flywheel with magnets
    - 2. Armature (laminated)
    - 3. Switch stop
    - 4. Coil
    - 5. Contact points
    - 6. Condenser
- B. Secondary system (high voltage)
    - 1. Spark plug
    - 2. High voltage wire

V. **Components of a solid state ignition system** (Transparency 4)

- A. Flywheel with magnets
- B. Trigger coil
- C. Resistor
- D. Transistorized rectifier (solid state switch)
- E. Diode rectifier
- F. Ignition coil
- G. Low voltage wire

(NOTE: The same secondary circuit components are used on the solid state ignition system that are used on the magneto ignition system.)

VI. **Components of a breakerless ignition system** (Transparency 5)

- A. Battery
- B. Flywheel
- C. Trigger module
- D. Ignition switch
- E. Alternator-stator

INFORMATION SHEET

F. Ignition coil assembly

G. Rectifier-regulator

H. Low voltage wire

I. Silicon rectifier (SCR)

(NOTE: The same secondary circuit components are used on the breakerless ignition system that are used on the magneto ignition system.)

VII. **Purpose of the ignition system components**

A. Battery — Source of electrical power

B. Ignition switch — Opens and closes the primary circuit from the battery or coil to the contact points

C. Coil — Transforms low voltage into high voltage necessary to jump the spark plug gap

D. Contact points — Make and break the primary circuit to allow the coil to produce high voltage at the spark plug

E. Condenser — Stores extra current as the contact points open to prevent arcing and burning

F. Breaker cam — Opens the contact points

G. Diode rectifier — Changes alternating (AC) current to direct (DC) current

H. Capacitor — Used in solid state ignition systems and operates like the condenser

I. Trigger coil — Generates a small amount of current that is used to activate the current from the capacitor

J. Resistor — Reduces voltage in the primary circuit to protect the contact points

K. Spark plug — Provides a spark gap inside the engine cylinder to ignite the fuel-air mixture

L. Low voltage wire — Carries low-voltage from the battery or armature to the primary side of the ignition coil

(NOTE: This is a wire with thin insulation.)

M. High voltage wire — Carries high voltage from the secondary side of the coil to the spark plug

(NOTE: This is a heavily insulated wire.)

INFORMATION SHEET

VIII. **Operation of the ignition systems** (Transparencies 1, 2, 4, 6, 7, and 8)

A. Battery

1. With the ignition switch on and the contact points closed, low voltage current flows from the battery through the primary windings of the coil and through the contact points to ground

2. The flow of low voltage current through the primary windings of the coil causes a magnetic field buildup

3. As the contact points open, current attempts to continue to flow across the point surfaces; the condenser is attached to the points to absorb this flow of current to prevent arcing

4. Stopping the flow of current causes the magnetic field of the coil to collapse across the secondary coil windings, causing a high voltage surge

5. The high voltage surge is directed from the secondary windings of the coil through the distributor cap and rotor and on to the spark plug to ground

B. Magneto

1. With the ignition switch on or the contact points closed, low voltage current is induced by magnets through the primary windings of the coil and through the contact points to ground

2. The flow of low voltage current through the primary windings of the coil causes a magnetic field buildup

3. As the contact points open, current attempts to continue to flow across the point surfaces; the condenser is attached to the points to absorb this flow of current to prevent arcing

4. Stopping the flow of current causes the magnetic field of the coil to collapse across the secondary coil windings, causing a high voltage surge

5. The high voltage surge is directed from the secondary windings of the coil through the secondary wire on to the spark plug to ground

C. Solid state

1. With the ignition switch on, low voltage current from the flywheel magnet induces alternating current (AC) in charge coil

INFORMATION SHEET

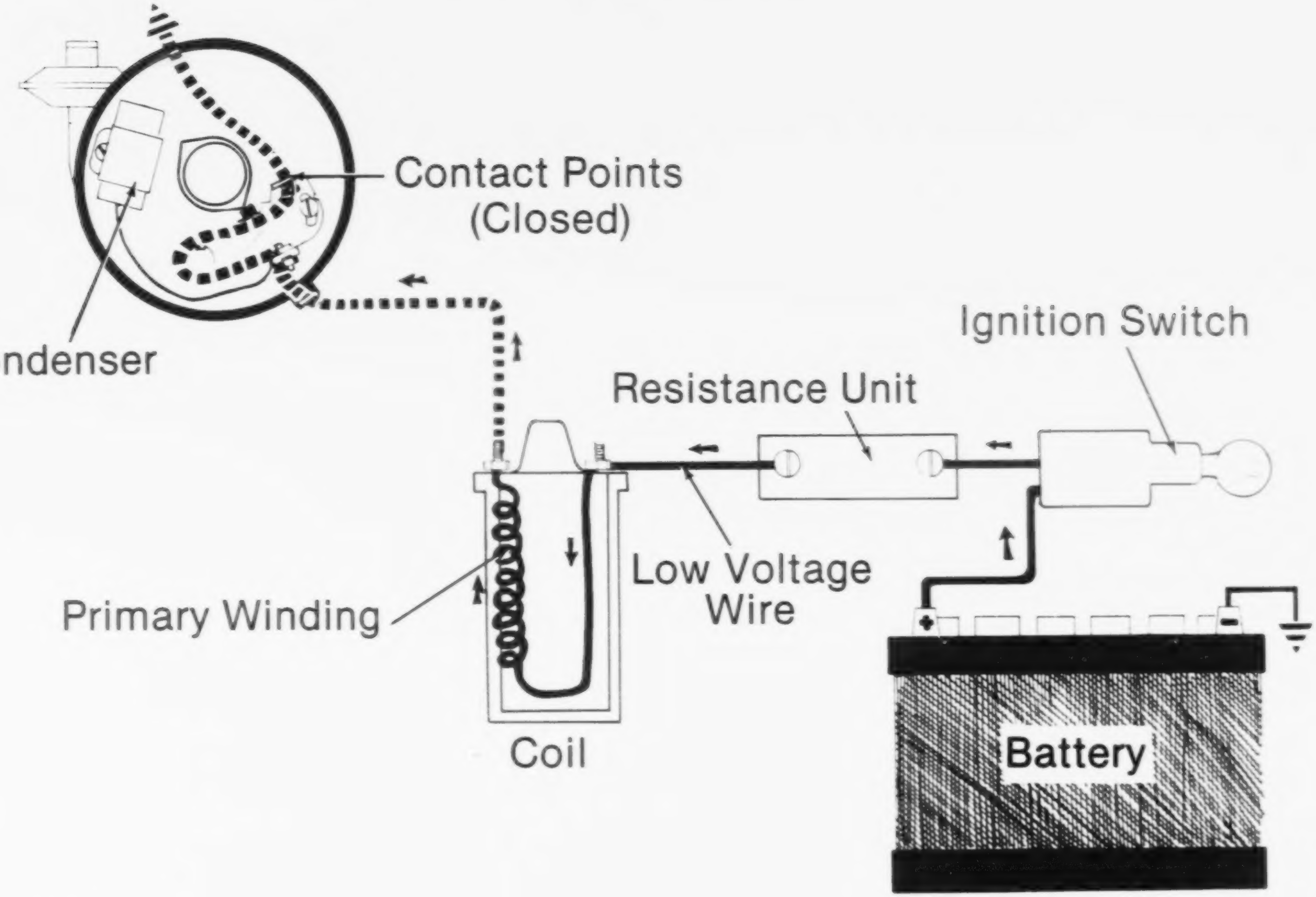
2. The AC current passes through a rectifier and changes to direct current (DC), which travels to the capacitor (condenser) where it is stored

3. The flywheel magnets pass the trigger coil and induce a small electrical charge, which turns on the silicon controlled rectifier (SCR)

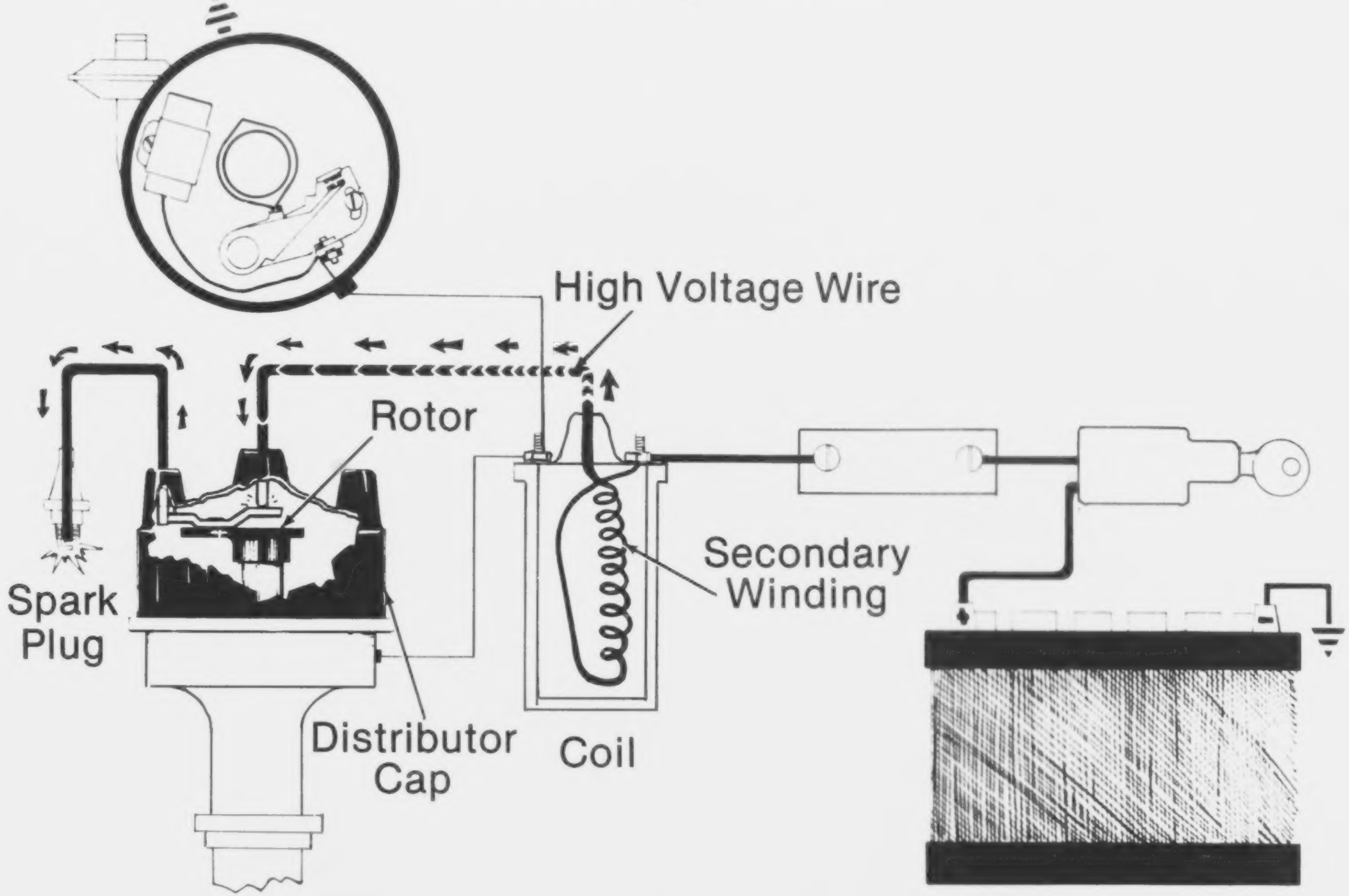
   (NOTE: This completes the circuit from the charged side of the high tension coil to the negative side of the capacitor.)

4. The instantaneous discharge of energy induces a very high density magnetic field around the primary winding of the coil, which cuts the secondary winding and thus creates sufficient energy to fire the spark plug

Primary Circuit


Contact Points
(Closed)
Condenser
Ignition Switch
Resistance Unit
Low Voltage
Wire
Primary Winding
Coil
Battery

Secondary Circuit


High Voltage Wire
Rotor
Spark Plug
Secondary Winding
Distributor Cap
Coil

TM 2

341

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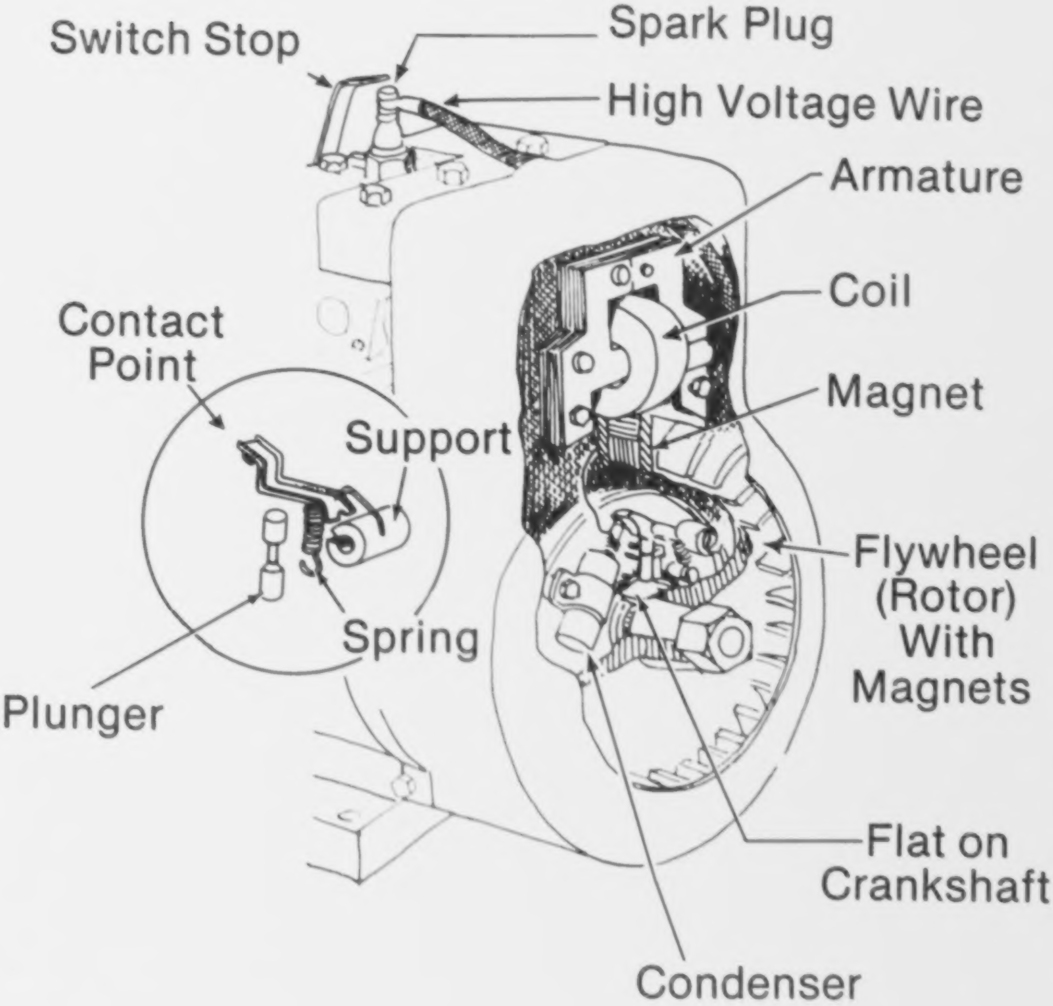
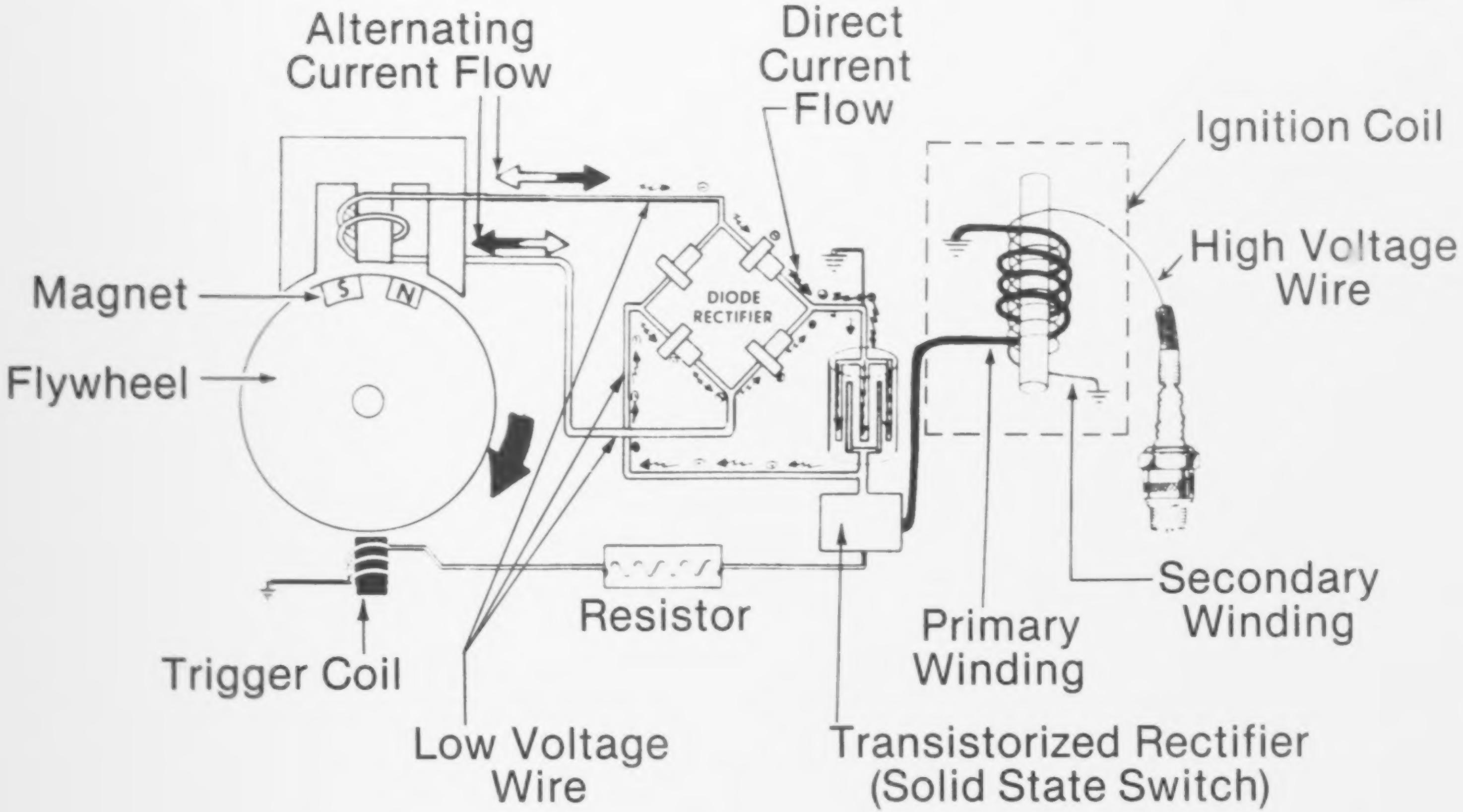
SE - 71-C

Magneto Ignition System


Switch Stop
Spark Plug
High Voltage Wire
Armature
Coil
Contact Point
Magnet
Support
Flywheel (Rotor) With Magnets
Spring
Plunger
Flat on Crankshaft
Condenser

Solid State Ignition System



Alternating Current Flow

Direct Current Flow

Ignition Coil

High Voltage Wire

Magnet

Flywheel

Secondary Winding

Primary Winding

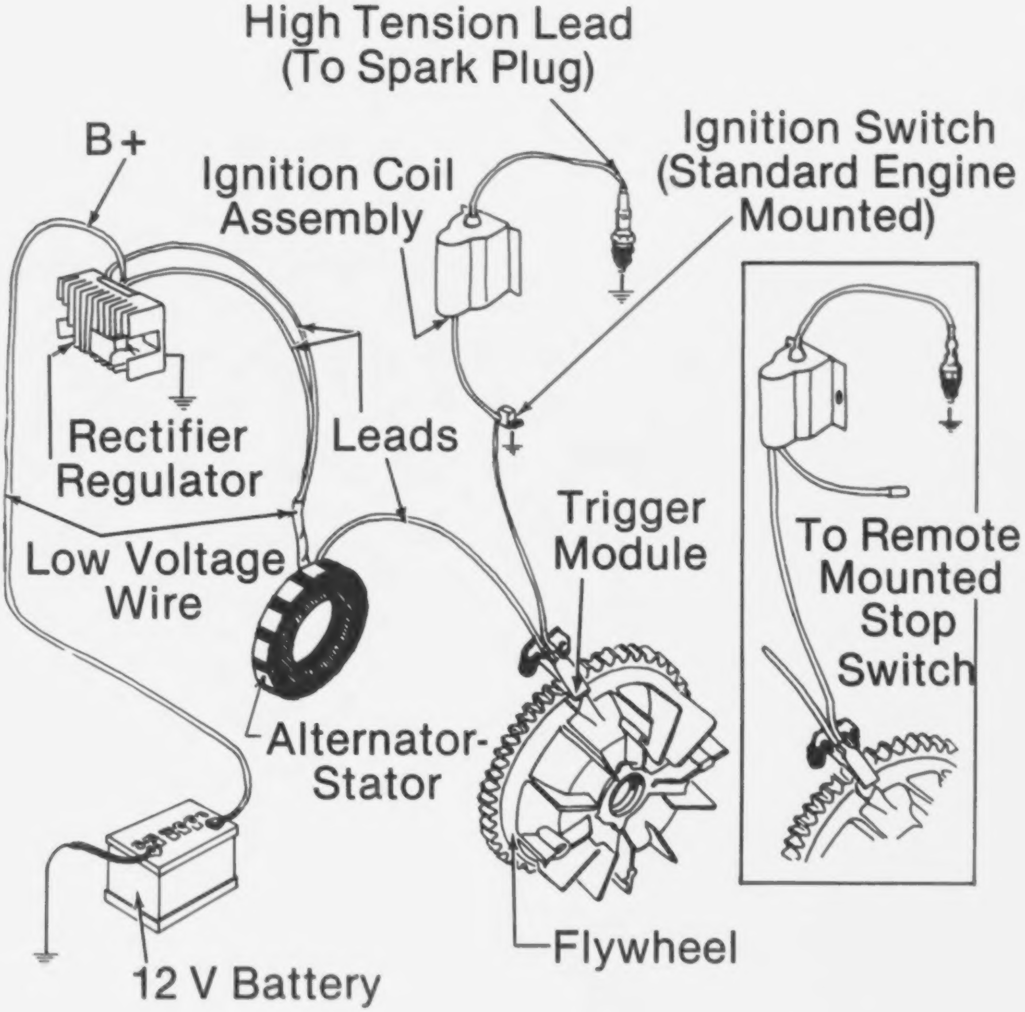
Resistor

Trigger Coil

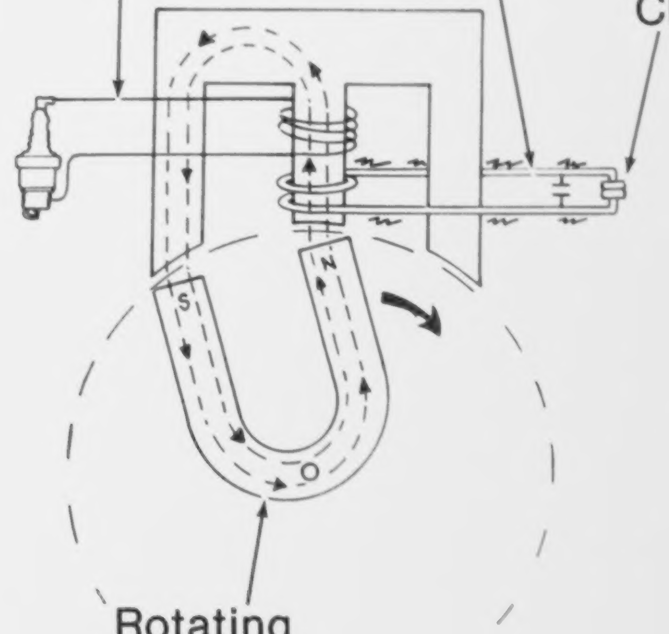
Low Voltage Wire

Transistorized Rectifier (Solid State Switch)

Breakerless Ignition System


High Tension Lead
(To Spark Plug)
B+
Ignition Coil
Assembly
Ignition Switch
(Standard Engine
Mounted)
Rectifier
Regulator
Leads
Trigger
Module
To Remote
Mounted
Stop
Switch
Low Voltage
Wire
Alternator-
Stator
Flywheel
12 V Battery

Principles of a Magneto

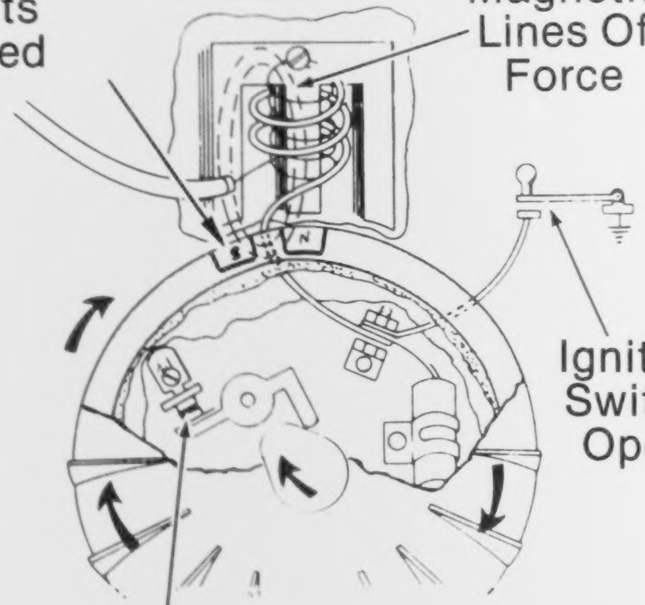


Secondary Circuit

Primary Circuit

Contact Points Closed

Rotating Permanent Magnet



Permanent Magnet

Magnetic Lines Of Force

Ignition Switch Open

Contact Points Closed

TM 6

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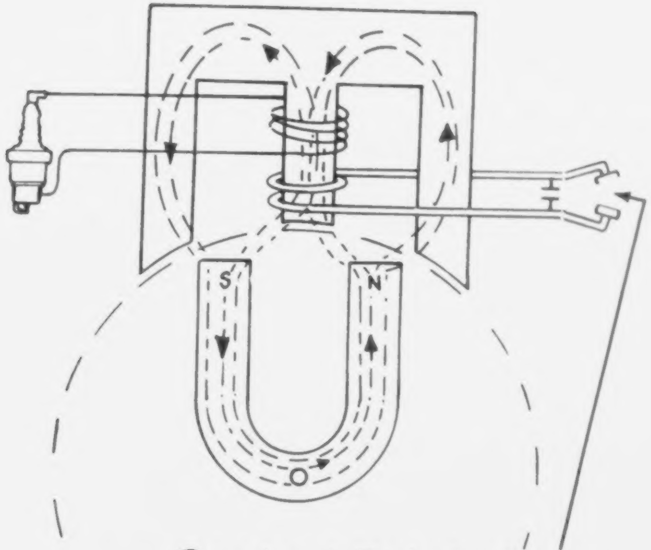
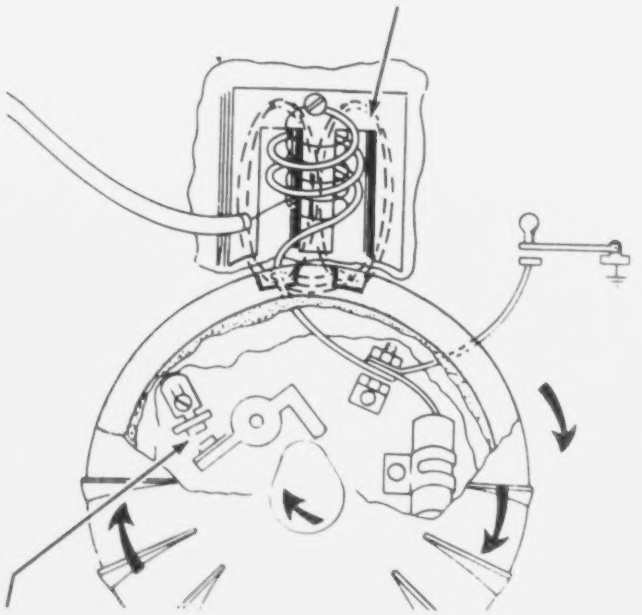
SE - 79-C

Principles of a Magneto

(Continued)



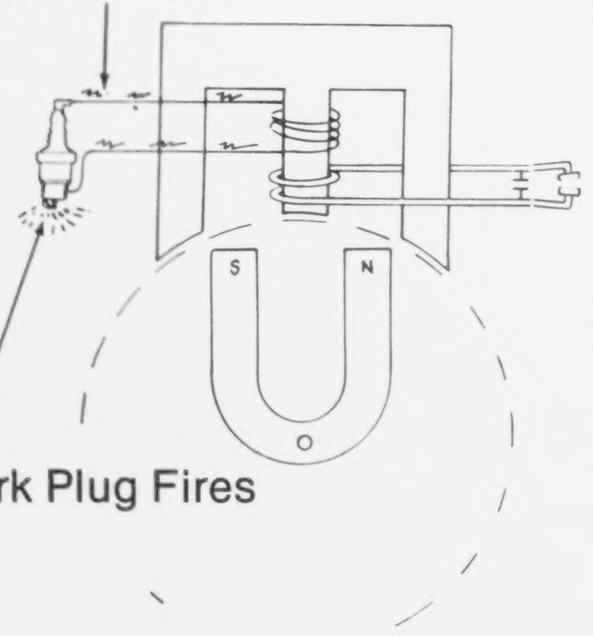
Contact Points Open

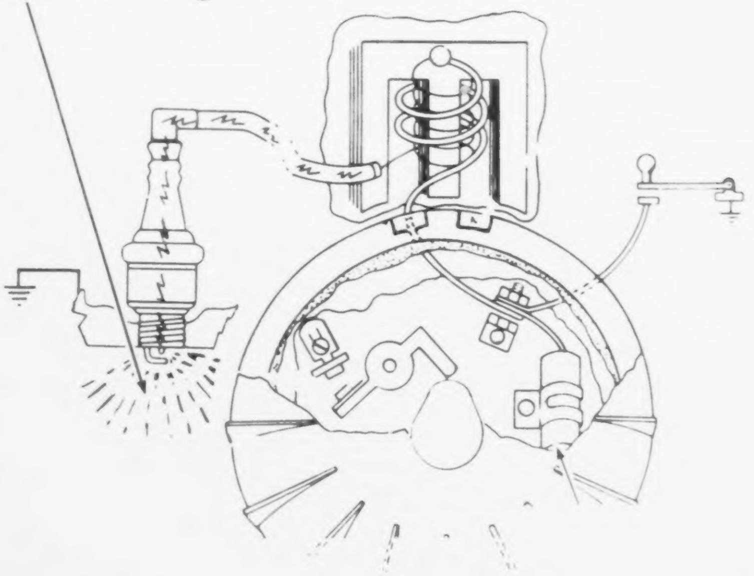


Contact Points Open

Principles of a Magneto

(Continued)


Current Flow
S
N
Spark Plug Fires


Spark Plug Fires

IGNITION SYSTEMS
UNIT II-C

JOB SHEET #1 — REMOVE, SERVICE, AND REPLACE SPARK PLUGS

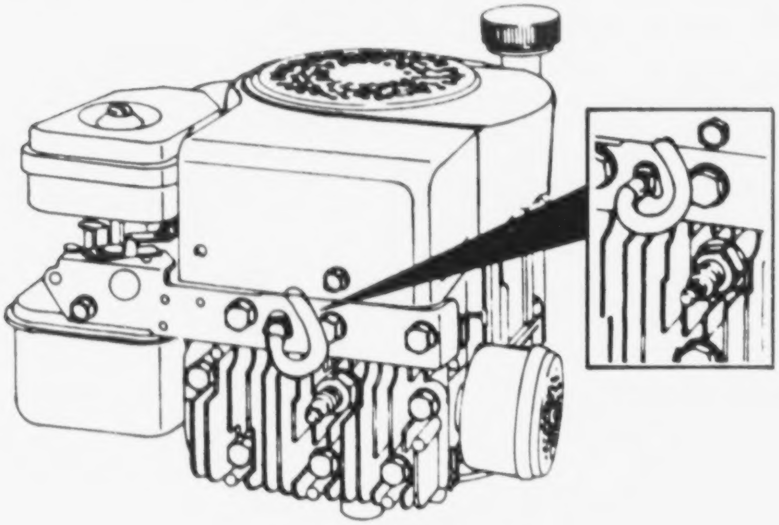
A. Tools and materials needed

1. Hand tool assortment
2. Wire feeler gauge
3. Ignition file
4. Wire brush
5. Spark tester
6. Safety glasses

B. Procedure

1. Clean around spark plug by blowing out dirt with compressed air
2. Secure engine to be serviced and disconnect spark plug wire; secure the wire in the V-notch above the spark plug or tape the wire in place on older models (Figure 1)

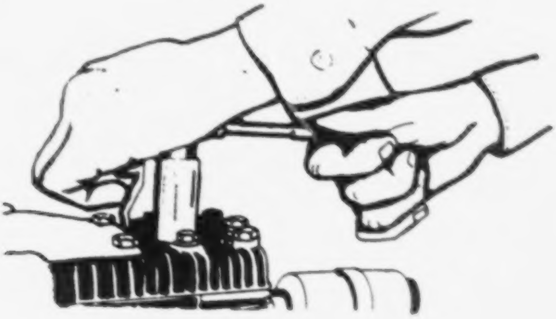
FIGURE 1



JOB SHEET #1

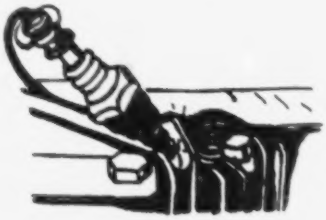
3. Loosen the spark plug one turn and blow any trapped dirt out with compressed air; remove spark plug (Figure 2)

FIGURE 2



4. Reconnect spark plug wire
5. Ground spark plug to engine (Figure 3)

FIGURE 3



6. Crank engine one or two turns
7. Observe spark at the electrode

(NOTE: If there is no spark or the spark is weak, proceed to next step.)

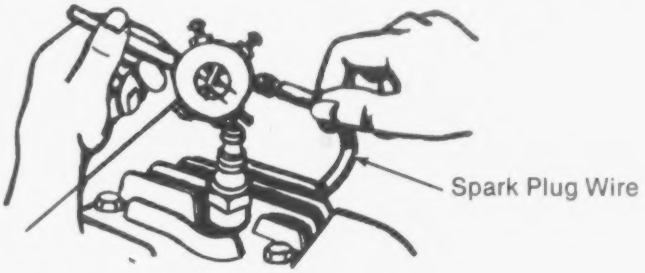
8. Disconnect the spark plug wire from the spark plug

JOB SHEET #1

9. Use spark tester to check ignition (Figure 4)

   (NOTE: Do not hold end of spark plug wire within 1/4 inch from the cylinder head.)

   FIGURE 4



10. Crank the engine one or two turns

11. Observe the spark

    (NOTE: If spark jumps gap on tester, the ignition system is okay; the trouble is in the spark plug.)

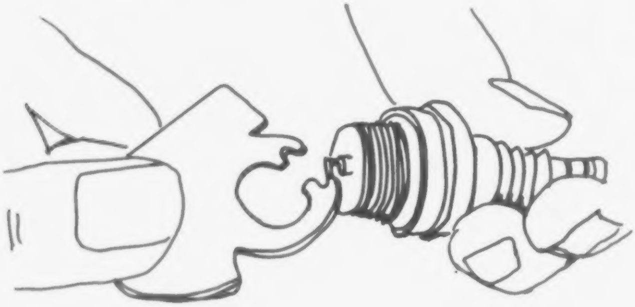
12. Service the spark plug

    a. Clean threads with a wire brush

       (NOTE: Using a spark plug cleaning machine is not recommended because this will void small engine warranties.)

    b. With a gap setter, bend the ground electrode away from the central electrode just enough to allow the ignition file to fit between the two electrodes (Figure 5)

       FIGURE 5



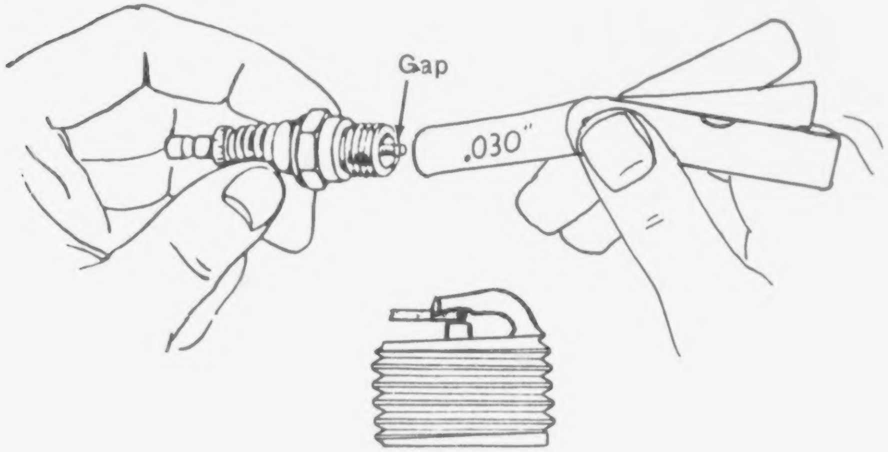
JOB SHEET #1

c. Using the ignition file, file the ground and central electrode until both have flat, shiny surfaces

d. Bend the ground electrode back into its original position; gap plugs to manufacturer's specifications

(NOTE: Use a wire gauge and bend only the ground electrode (Figure 6)

FIGURE 6



13. Install spark plug **by hand** until seated snugly then tighten

    (NOTE: Use caution when starting the spark plug to avoid cross threading.)

14. Torque the spark plug to manufacturer's recommendations
15. Replace the spark plug wire
16. Have instructor evaluate work
17. Clean work area and return tools to proper location

IGNITION SYSTEMS
UNIT II-C

JOB SHEET #2 — REMOVE AND REPLACE CONTACT POINTS AND CONDENSER

A. Tools and materials

1. Flywheel removal tools
2. Ignition tools and wrenches
3. Feeler gauge set .010 — .025
4. Screwdrivers
5. Cam lubricant
6. Shop towels
7. Electrical cleaner
8. Hand tool assortment
9. Safety glasses

B. Procedure (Removal) — Applies to Briggs and Stratton only

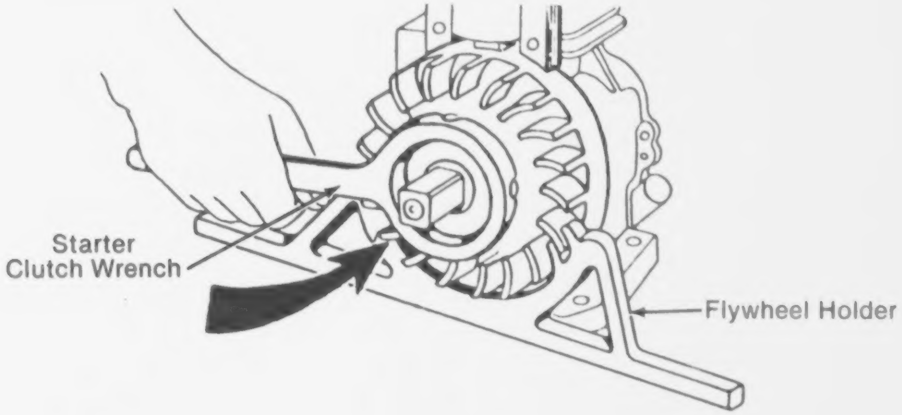
1. Find location of points and condenser

   (NOTE: On most engines this will be under the flywheel. Some will be located externally on the side of the block.)

2. Remove engine shroud and any parts necessary to get at the flywheel
3. Remove flywheel

   (NOTE: Check for left-hand threads on crankshaft; use special flywheel removal tools as required. See Figures 1, 2, and 3.)

   FIGURE 1



JOB SHEET #2

FIGURE 2

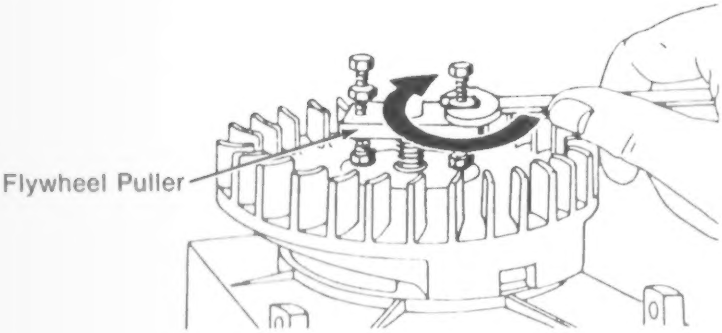
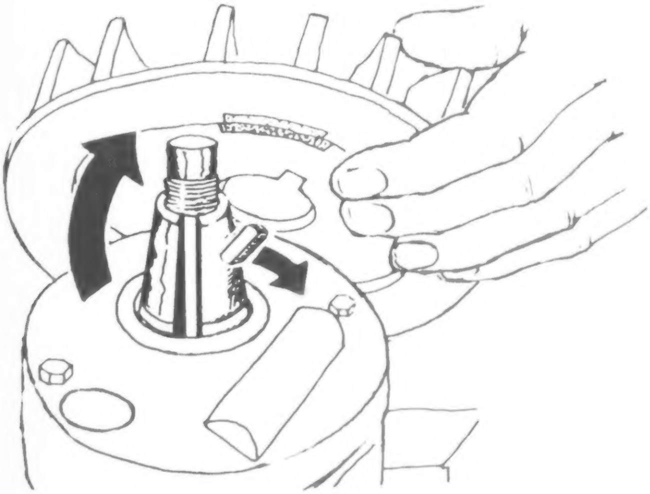


FIGURE 3



4. Inspect flywheel and key

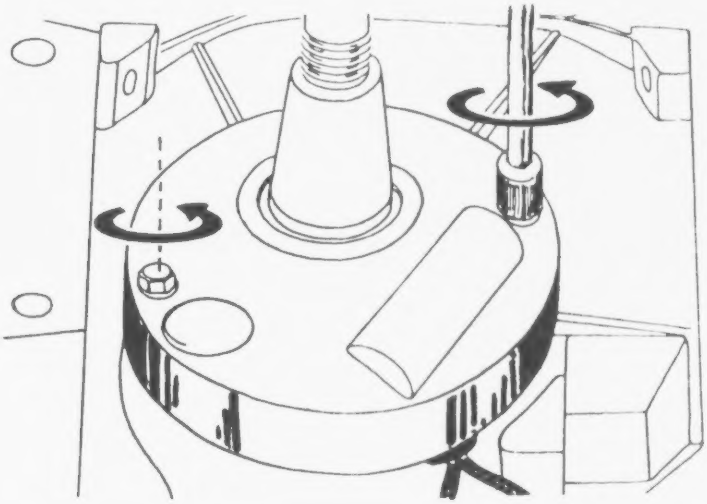
(NOTE: Check condition of flywheel keyway and magnet. If the magnet is rusty, clean with emery cloth and cleaner brush. Check key closely for damage. If damaged, replace with new key.)

JOB SHEET #2

5. Remove breaker point dust cover (Figure 4)

   (NOTE: Some covers have a sealer at the point where the wires enter. Save this for reuse.)

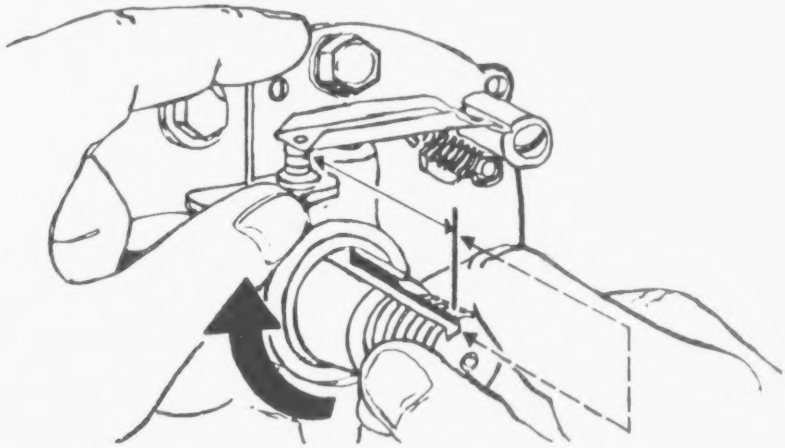
   FIGURE 4



6. Determine location and condition of all wires, screws, and breaker cam (Figure 5)

   (NOTE: Turn crankshaft clockwise with your hand until keyway is in line with the breaker plunger. At this point cam is at its highest position.)

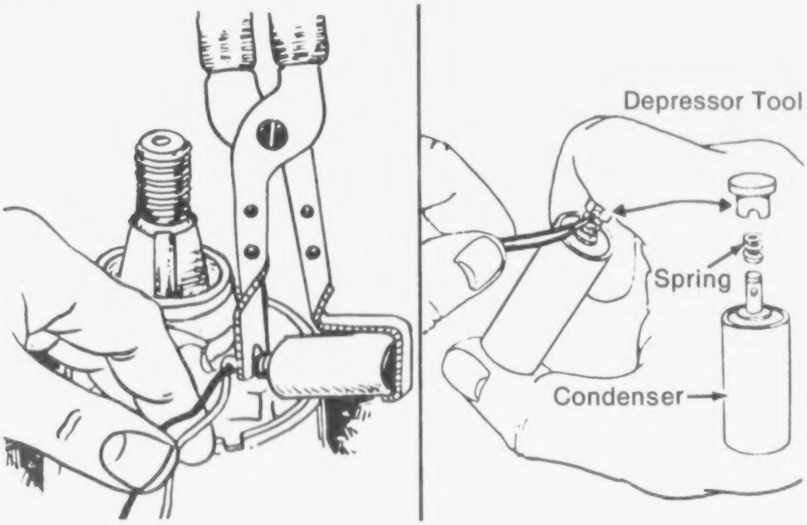
   FIGURE 5



JOB SHEET #2

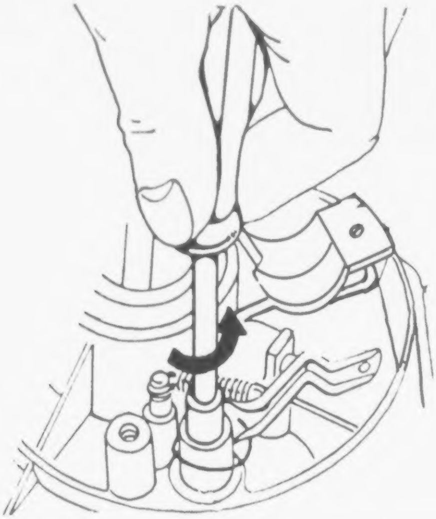
7. Remove screw holding condenser in place; using the depressor tool, disconnect contact point primary lead and ground wire (Figure 6)

FIGURE 6



8. Loosen mounting bolt and remove the movable contact point (Figure 7)

FIGURE 7

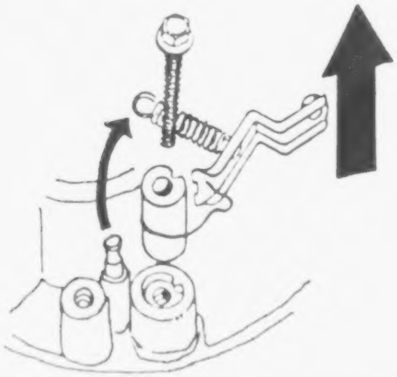


(NOTE: When mounting bolt is loosened, the contact point loses its tension.)

JOB SHEET #2

9. Lift spring from post and remove mounting bolt, contact point, mounting post, and spring (Figure 8)

FIGURE 8

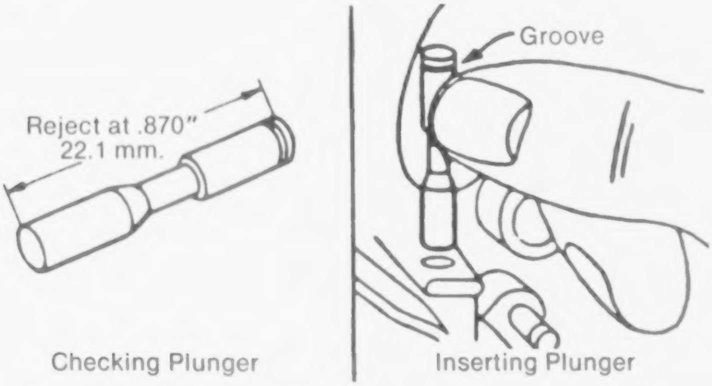


(NOTE: Keep the mounting bolt. Always replace old contact points with a new set.)

10. Inspect the breaker point plunger

(CAUTION: The plunger must be inserted with groove at the top when installed or oil will enter the breaker box [see Figure 9].)

FIGURE 9



Checking Plunger

Inserting Plunger

11. Clean the point and condenser area with an approved electrical cleaner

(NOTE: Check the oil seal located in the point area to be sure it is not leaking oil onto the points.)

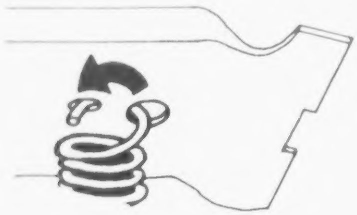
12. Lubricate the breaker cam with a light coating of cam lubricant

JOB SHEET #2

C. Procedure (Reassembly) — Applies to Briggs and Stratton only

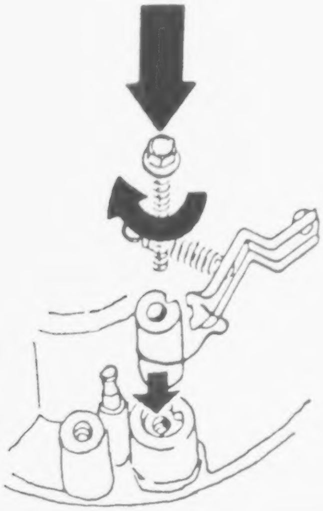
1. Install new movable contact point; hook open loop of spring through large hole then through small hole (Figure 1)

FIGURE 1



2. Place mounting bolt into post and tighten (Figure 2)

FIGURE 2

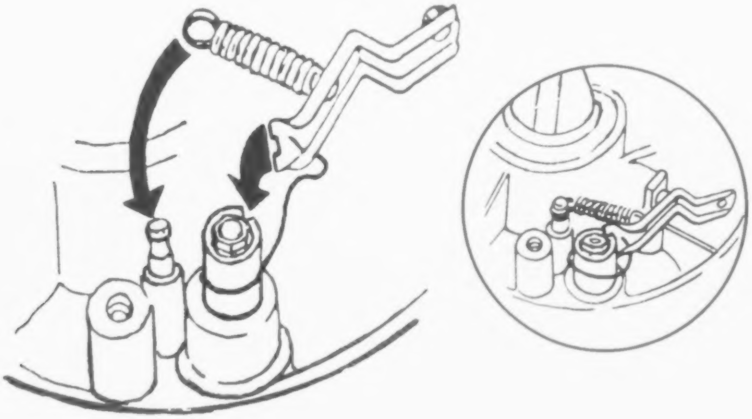


(NOTE: Handle movable point carefully to prevent breaking wire connection to post.)

JOB SHEET #2

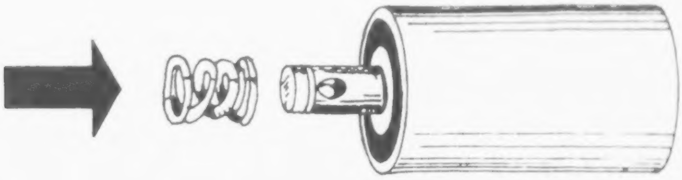
3. Fit end of contact point arm into groove in mounting post; hook closed loop of spring onto the small post (Figure 3)

FIGURE 3



4. Place spring on condenser and hold it in place (Figure 4)

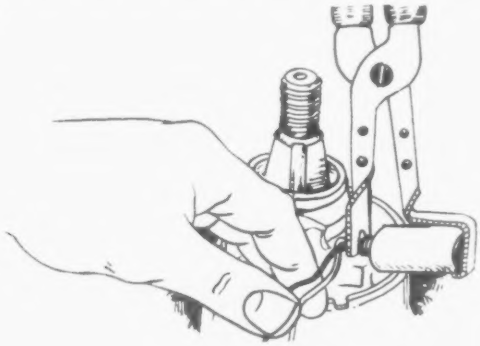
FIGURE 4



(NOTE: Flatten wire ends around fixed point.)

5. Compress spring and slip the two wires into the hole on condenser (Figure 5)

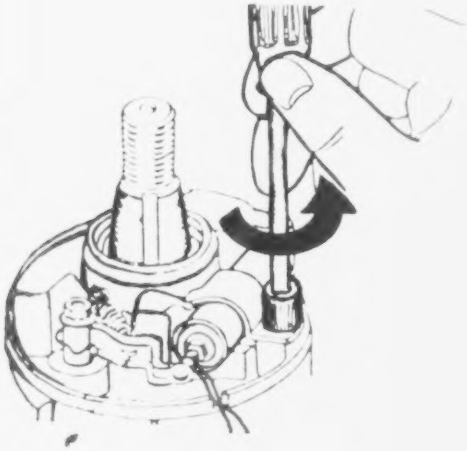
FIGURE 5



JOB SHEET #2

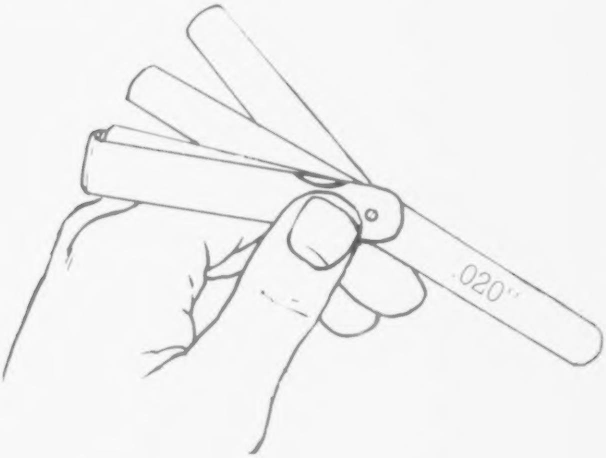
6. Install new condenser and clamp in place; tighten the clamp bolt (Figure 6)

FIGURE 6



7. Select correct size feeler gauge (Figure 7)

FIGURE 7



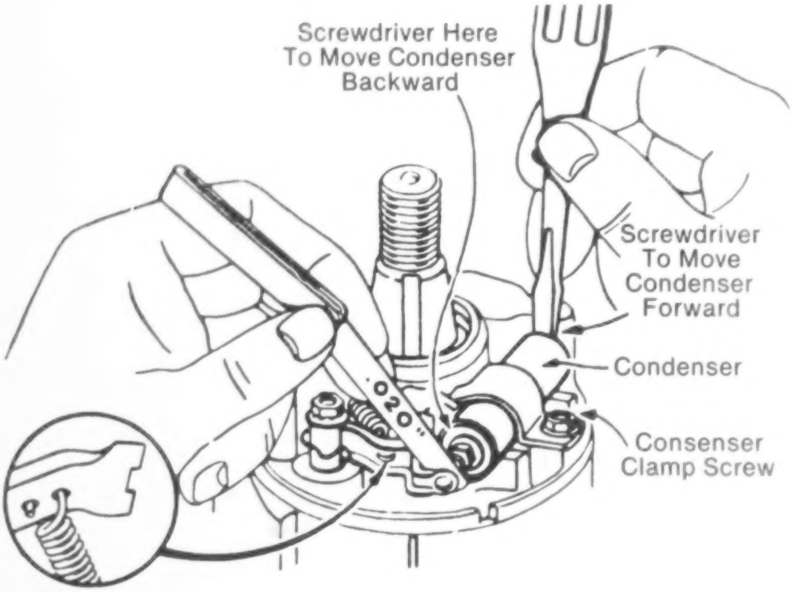
(NOTE: Make sure the crankshaft keyway is lined up with the breaker plunger.)

JOB SHEET #2

8. Tighten the condenser clamp; place feeler gauge between contact points, push condenser forward with a screwdriver, and set the points at .020 (Figure 8)

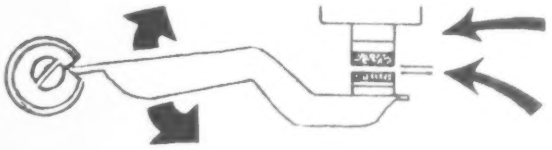
   (NOTE: Make sure condenser clamp is secured. The condenser should move back and forth to properly set points.)

   FIGURE 8


Screwdriver Here To Move Condenser Backward
Screwdriver To Move Condenser Forward
Condenser
Consenser Clamp Screw
.020"

9. Make sure the two contact points fit squarely together and not at an angle; adjust the movable contact point, if necessary (Figure 9)

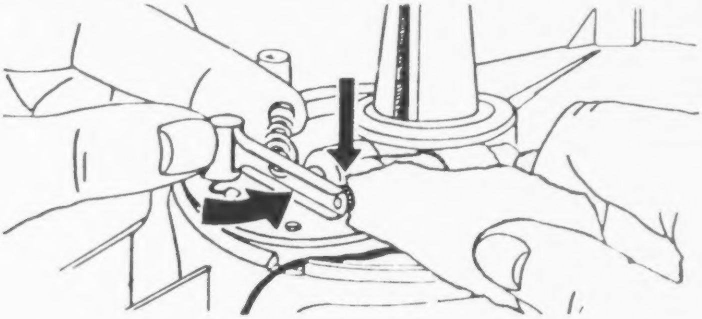
   FIGURE 9



JOB SHEET #2

10. Open the points and place a piece of paper between the points; close the points with paper still between them as this removes any grease on the points (Figure 10)

FIGURE 10

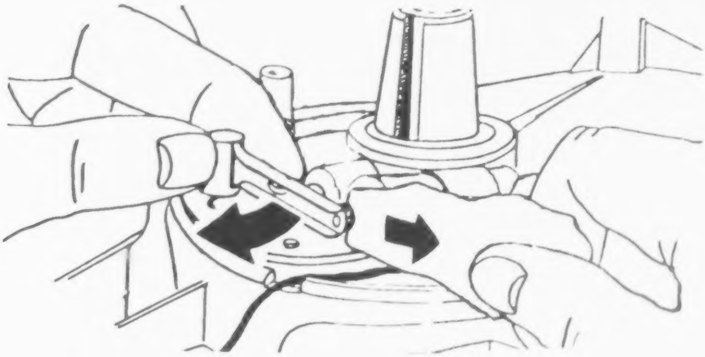


(NOTE: Use a nonfibrous paper.)

11. Open points and remove the paper (Figure 11)

(CAUTION: Always open points when removing paper.)

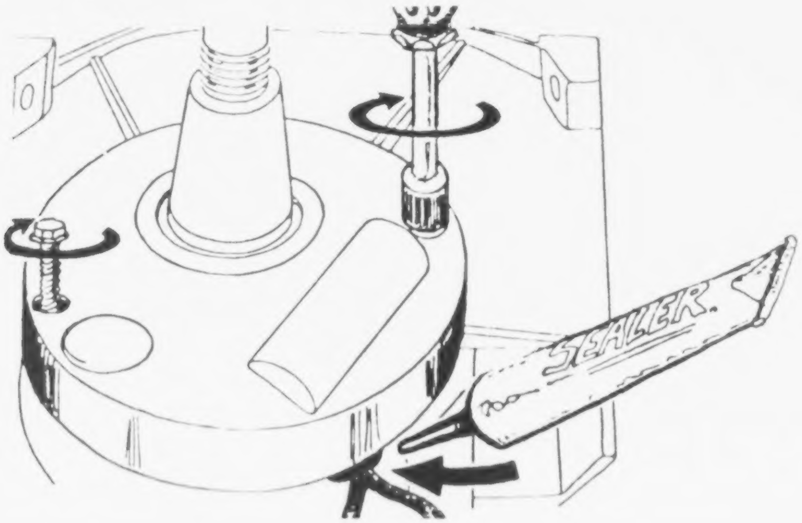
FIGURE 11



JOB SHEET #2

12. Place sealer around wiring; replace dust cover and bolts on the points and condenser (Figure 12)

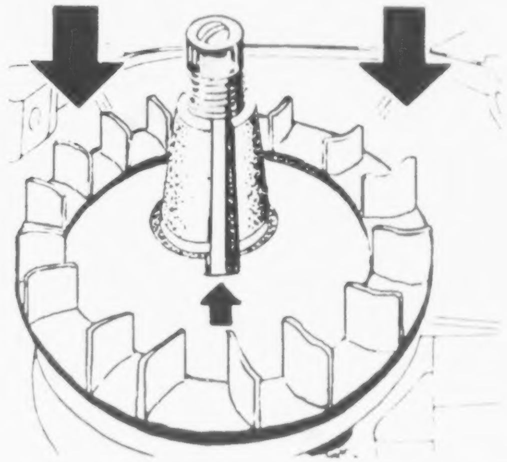
FIGURE 12



(NOTE: Do not overtighten the bolts because they will strip easily.)

13. Place flywheel on crankshaft and line up the keyway (Figure 13)

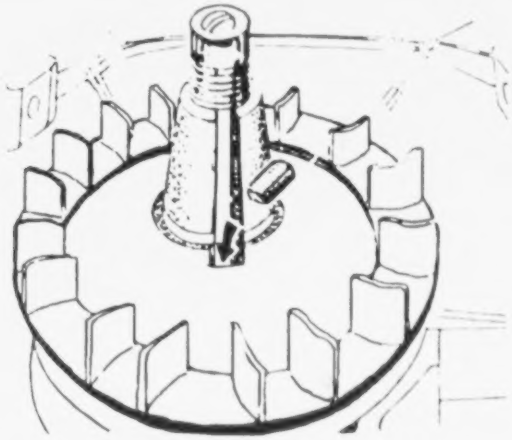
FIGURE 13



JOB SHEET #2

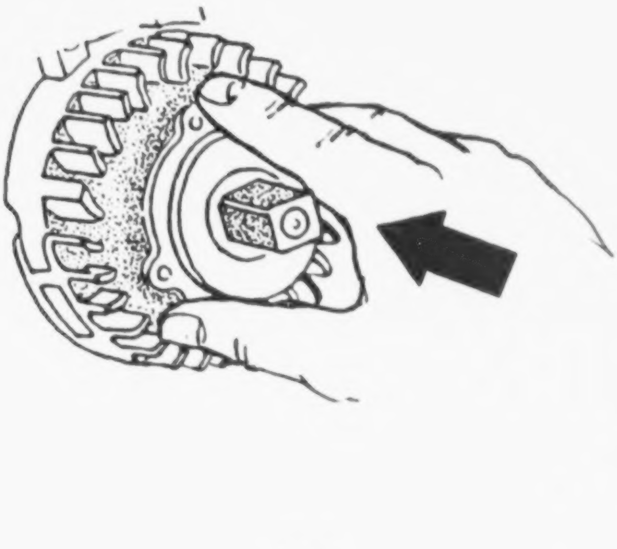
14. Place flywheel key in keyway (Figure 14)

FIGURE 14



15. Place starter clutch onto crankshaft (Figure 15)

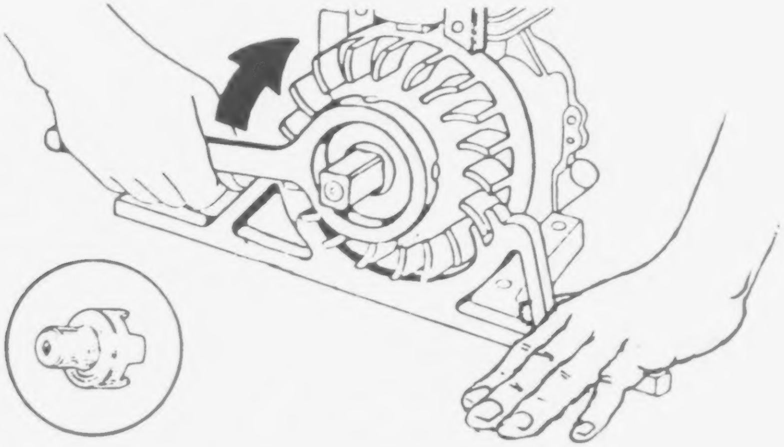
FIGURE 15



JOB SHEET #2

16. Place flywheel holder on flywheel and starter clutch wrench on starter clutch; while holding the flywheel holder, tighten starter clutch (Figure 16)

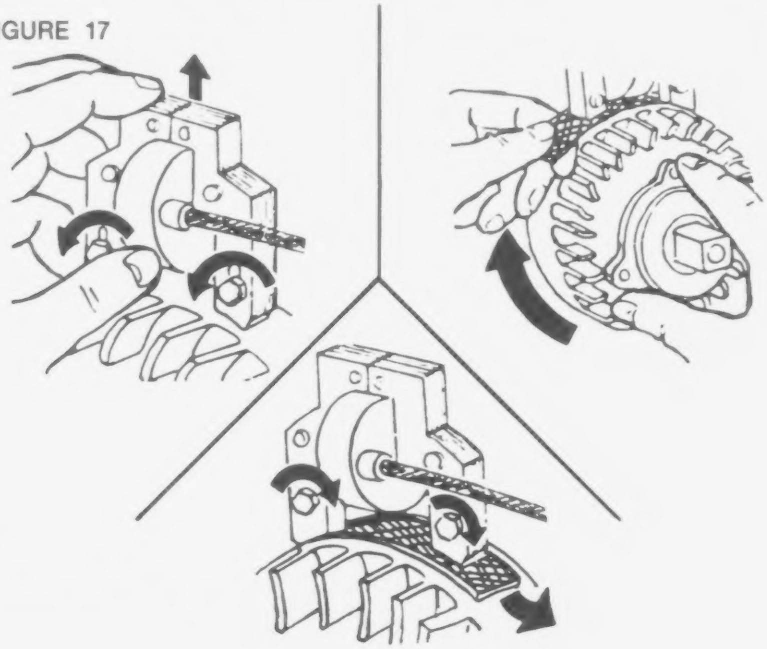
FIGURE 16



(NOTE: Torque flywheel to 55 ft.-lbs. using starter clutch wrench with 1/2" drive torque wrench.)

17. Check air gap by loosening the two armature bolts, inserting .010 shim stock between flywheel and armature, and rotating the flywheel until magnets pull armature down to shim stock; tighten armature bolts and remove shim stock (Figure 17)

FIGURE 17



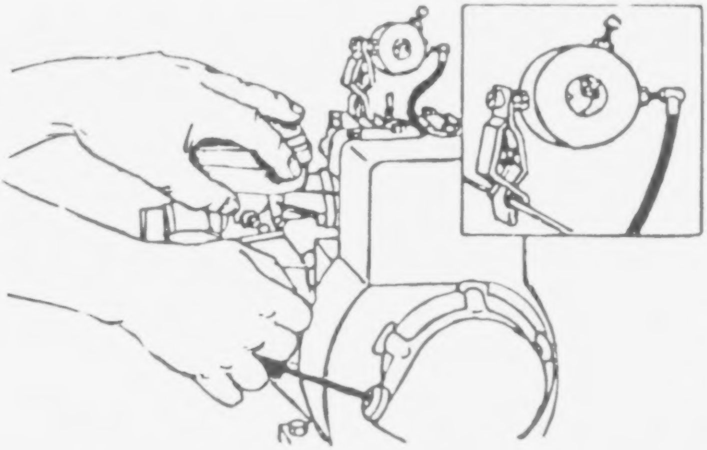
JOB SHEET #2

18. Attach flywheel screen over starter clutch

19. Replace flywheel shroud and tighten the bolts

20. Check out ignition (Figure 18)

FIGURE 18



(NOTE: Spark should be a bright blue and jump the .166" tester gap.)

21. Reconnect the spark plug wire

22. Have instructor evaluate work

23. Clean work area and return tools to their proper places

IGNITION SYSTEMS
UNIT II-C

JOB SHEET #3 — TEST THE COIL, CONDENSER, ARMATURE, AND FLYWHEEL MAGNETS

A. Tools and materials needed

1. Hand tool assortment
2. Ignition analyzer
3. Small thin cardboard (post card)
4. Electrical system cleaner
5. Shop towels
6. Safety glasses

B. Procedure

1. Remove all parts necessary to get at coil and armature
2. Determine correct location of coil and armature

   (NOTE: If there are not locating marks (arrows, dots, etc.) to accurately locate coil or armature, mark it and the engine block before removing. Use a small center punch or chisel to mark with.)

3. Remove coil and armature

   (NOTE: It is possible to test the coil and armature without removing it from the engine.)

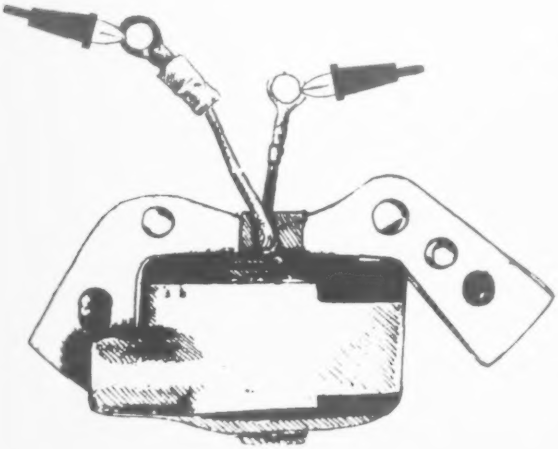
JOB SHEET #3

4. Test coil and armature

   a. Test primary resistance

      1) Following instructions for tester, connect leads (Figure 1)

         FIGURE 1



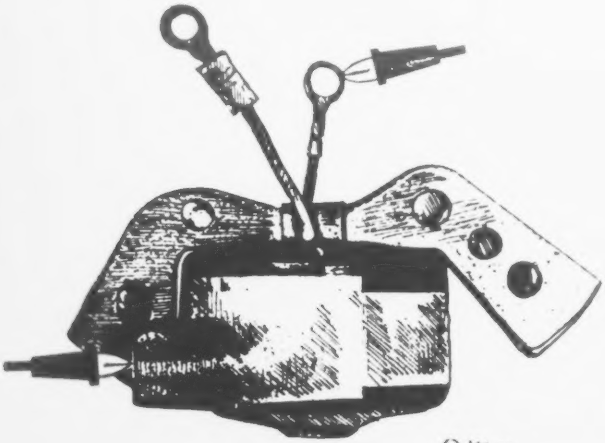
      2) Read ohmmeter

         (NOTE: Reading must be of value shown on engine specification sheet.)

   b. Test continuity

      1) Following instructions for tester, connect leads (Figure 2)

         FIGURE 2



JOB SHEET #3

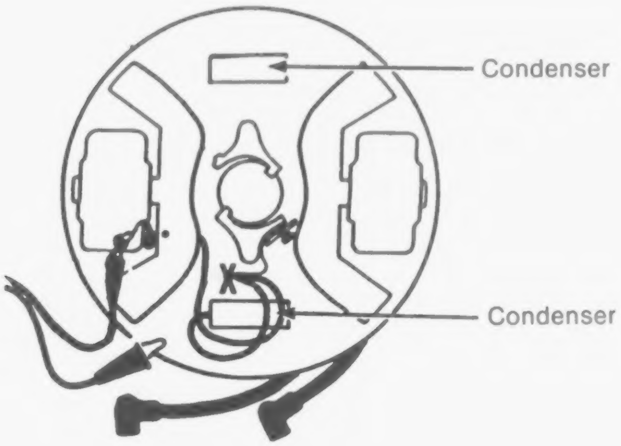
2) Read ohmmeter

(NOTE: Shorted windings are indicated by a lower than specified value. A broken winding is indicated by readings higher than the specified value.)

c. Test coil ground

1) Following instructions for tester, connect leads (Figure 3)

FIGURE 3



2) Read ohmmeter

(NOTE: Coils not permanently grounded should not indicate any pointer movement when tested. Coils permanently grounded must show a full deflection of the meter needle to the right of the scale.)

d. Test power

1) Following instructions for tester, properly connect test leads

2) Advance current control knob until specified operating amperage is reached on scale

(NOTE: If there is not spark or it is faint or intermittent, the coil is bad.)

c. If the coil fails any of the tests, replace it with a new coil

JOB SHEET #3

5. Replace all defective parts

6. Test flywheel magnets

   (NOTE: Hold a screwdriver one inch from the magnet. It should be strongly attracted to the magnet. Most magnets are damaged by dropping the flywheel, or storing flywheels nested in one another.)

7. Replace bad magnets

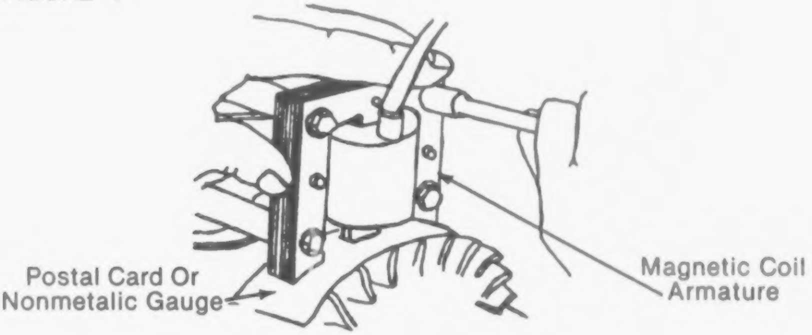
   (NOTE: Usually the whole flywheel must be replaced.)

8. Install coil and armature in correct position

   (NOTE: Do not overtighten mounting screws because these threads are easy to strip.)

9. Follow manufacturer's specifications for clearances, adjustments, and torque setting (Figure 4)

   FIGURE 4



10. Install all other parts on engine

11. Start engine and adjust to recommended specifications

12. Have instructor evaluate work

13. Clean up work area and return tools to proper location

IGNITION SYSTEMS
UNIT II-C

JOB SHEET #4 — TEST AND ADJUST A SOLID STATE IGNITION SYSTEM

A. Tools and materials needed

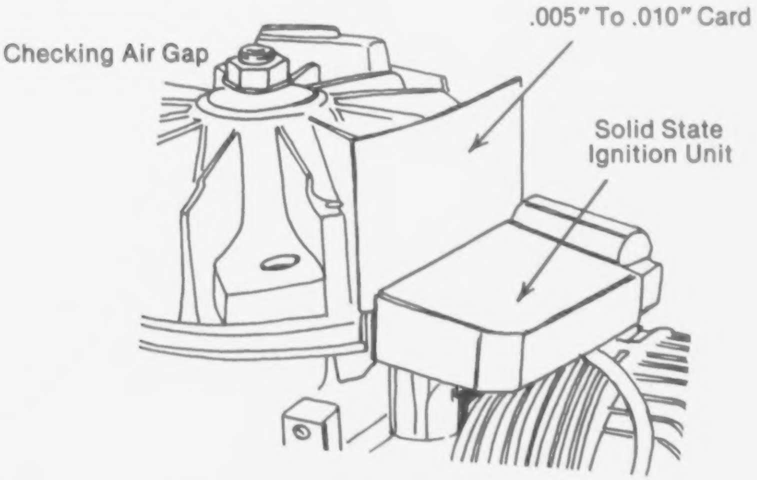
1. Hand tool assortment
2. Set flat feeler gauge .005 — .010
3. Ohmmeter
4. Safety glasses

B. Procedure

1. Remove shroud covering flywheel
2. Check air gap at trigger assembly and projection on the flywheel; set about .010 (± .005) Figure 1)

   (NOTE: .010 will give the fastest starting. Be sure flat surfaces on trigger and projection are parallel to each other.)

   FIGURE 1



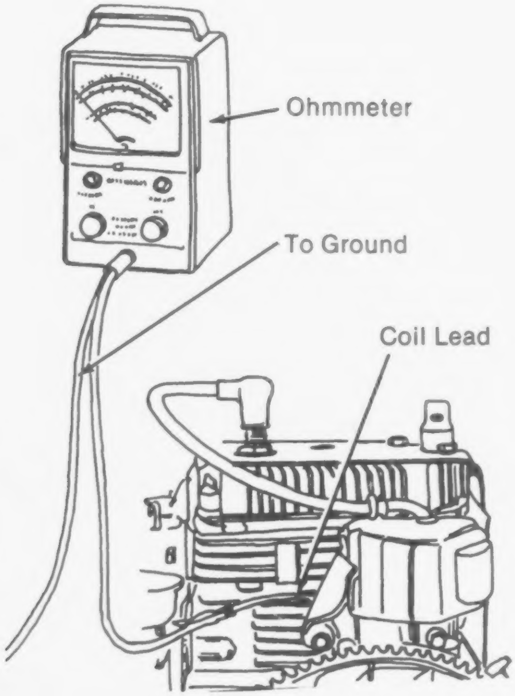
3. Retighten cap screws after gap is readjusted
4. Remove high tension lead from terminal on coil

JOB SHEET #4

5. Insert one ohmmeter lead in coil terminal and the other to the coil mounting bracket (Figure 2)

   (NOTE: Consult appropriate service manual for exact resistance.)

   FIGURE 2



6. Connect one tester lead to the coil mounting bracket and the other to the ignition switch wire

   (NOTE: Continuity should *not* be indicated here.)

7. Replace ignition coil assembly if wrong or widely varying results are obtained from either of these tests

JOB SHEET #4

8. Test the trigger module

    a. Connect one tester lead to the AC inlet lead on trigger module and other to lead on trigger side of ignition switch

    (NOTE: This should show continuity in one direction but not the other; reverse leads to check this.)

    b. Connect one tester lead to the trigger module mounting bracket and the other to the AC inlet lead to the module

    (NOTE: Continuity should be indicated in one direction but not the opposite; reverse leads to check this.)

    c. Disconnect leads and remove trigger from the engine

    d. Test with a flashlight type tester

        1) Connect one lead to the 1 terminal and the other to the trigger mounting bracket

        2) Lightly tap magnet with a metal object

        (NOTE: Light should come on and stay on until magnet is tapped again; this indicates that the SCR is operating properly.)

    e. Reinstall trigger

    f. Reset the air gap

    (NOTE: Replace the trigger module if wrong results are obtained from any of these tests.)

9. If ignition trouble persists after the system checks out in each of the preceding tests, the AC leads or ignition windings are probably faulty; replace stator assembly in this event

10. Have instructor evaluate work

11. Clean up work area and return tools to proper location

IGNITION SYSTEMS
UNIT II-C

JOB SHEET #5 — PERFORM A COIL POWER TEST

A. Tools and materials needed

1. Hand tool assortment
2. Ignition analyzer

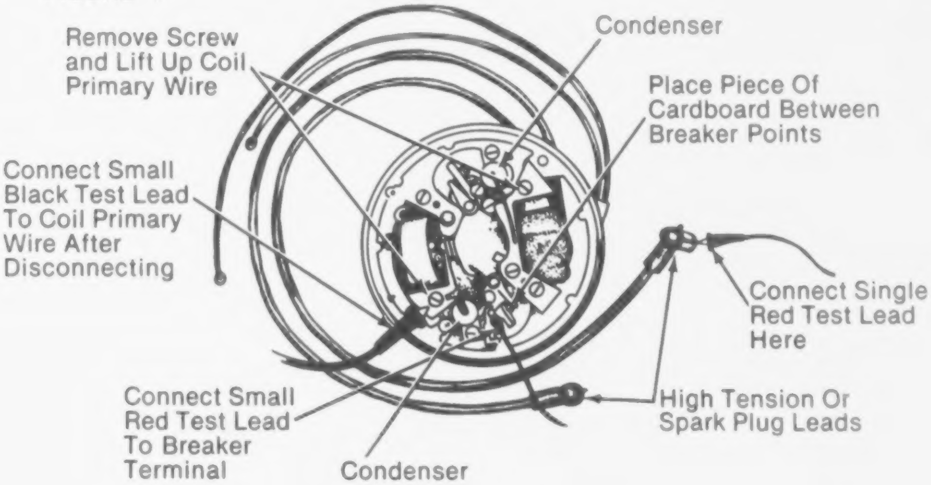
   (NOTE: The Merc-O-Tronic Ignition Analyzer is used in this job sheet.)

3. Safety glasses
4. Shop towels

B. Procedure

1. Remove all parts necessary to get at ignition system (Figure 1)

FIGURE 1


Remove Screw and Lift Up Coil Primary Wire
Condenser
Place Piece Of Cardboard Between Breaker Points
Connect Small Black Test Lead To Coil Primary Wire After Disconnecting
Connect Single Red Test Lead Here
High Tension Or Spark Plug Leads
Connect Small Red Test Lead To Breaker Terminal
Condenser

2. Read operator's manual and determine correct location of ignition parts and how to make proper connections for coil power test

   (NOTE: It is not necessary to remove magneto assembly from engine or parts from stator plate assembly.)

3. Place a piece of cardboard between breaker points to insulate (Figure 1)

JOB SHEET #5

4. Connect small black test lead to coil primary ground wire (Figure 1)

5. Connect small red test lead to coil primary lead or breaker point assembly terminal (Figure 1)

6. Connect single red test lead to terminal spark plug wire (Figure 1)

7. Turn the current control knob to extreme left, beyond "LO" position

8. Turn selector switch to position No. 1 (Coil Power Test)

9. Slowly turn current control knob clockwise and note the current value on Scale No. 1

10. See manufacturer's specifications for operating amperage of the coil you are testing

    (NOTE: There should be a steady bright blue fire which indicates a very good coil.)

11. If you have an intermittent, faint spark or no spark the coil is defective and should be replaced

12. Proceed to the coil high speed test

13. Continue turning the current control knob clockwise to the right, for maximum reading of meter

    (NOTE: The spark gap should fire steadily.)

14. If you have an intermittent, faint spark or no spark the coil is defective and should be replaced

    (NOTE: Complete this test as quickly as possible to prevent damage to coil.)

15. Turn selector switch and power control to "OFF" position

16. Remove all test leads

17. Replace defective coil

18. Install all other parts on engine

19. Start engine and adjust to recommended specifications

20. Have instructor evaluate work

21. Clean work area and return tools to their proper places

IGNITION SYSTEMS
UNIT II-C

JOB SHEET #6 — CHECK IGNITION TIMING USING A DIAL INDICATOR (TECUMSEH ENGINES)

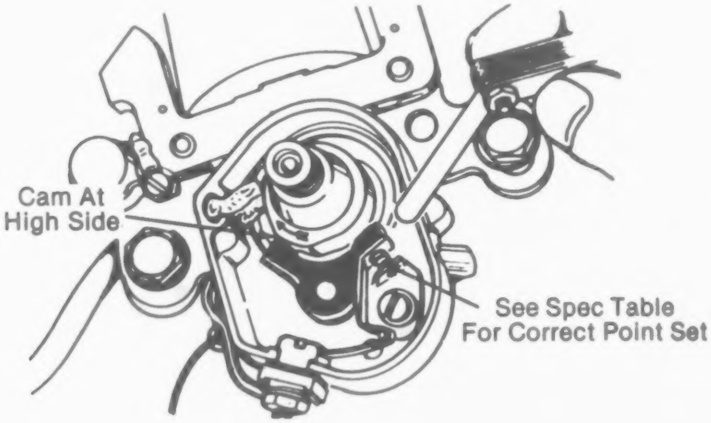
A. Tools and materials needed

1. Hand tool assortment
2. Dial indicator
3. Continuity tester
4. Safety glasses

B. Procedure

1. Remove engine shroud and exterior parts
2. Remove flywheel
3. Set the point gap and align (Figure 1)

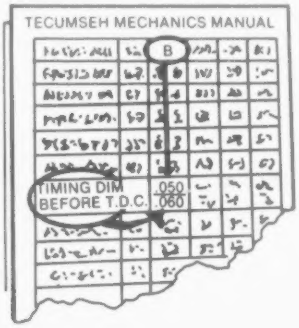
FIGURE 1


Cam At
High Side
See Spec Table
For Correct Point Set

JOB SHEET #6

4. Check manual for BTDC specifications (Figure 2)

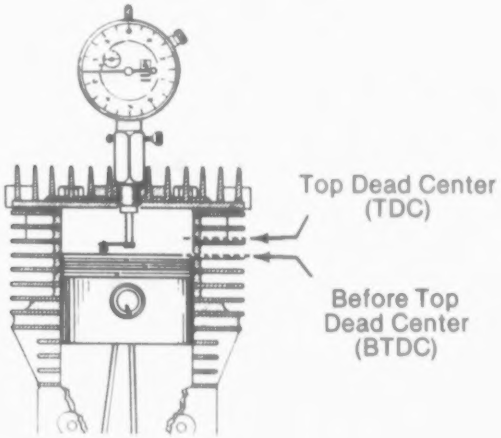
FIGURE 2


TECUMSEH MECHANICS MANUAL
B
TIMING DIM
BEFORE T.D.C.
.050
.060

5. Using dial indicator move piston up to Top Dead Center (TDC) and then set Before Top Dead Center (BTDC) per specifications table (Figure 3)

   (NOTE: Turn counterclockwise to move piston a greater amount than specifications state. Then turn clockwise bringing piston upward to the stated specifications. This elevates any looseness that might be present in the connecting rod, camshaft or other moving parts.)

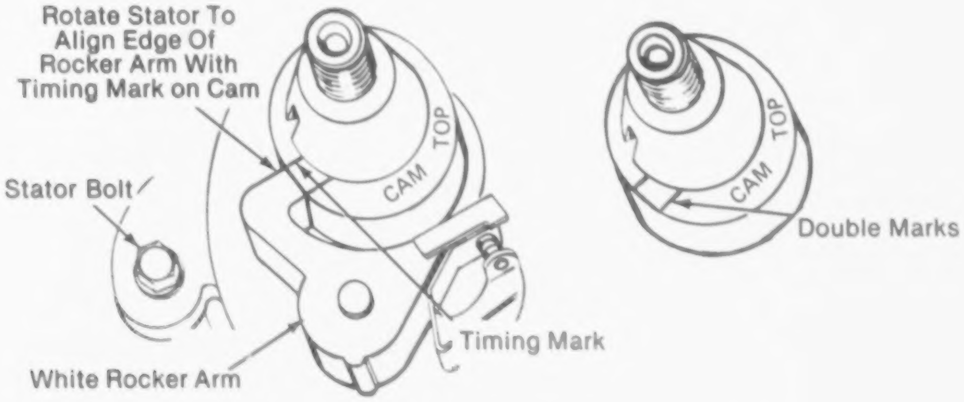
FIGURE 3


Top Dead Center
(TDC)
Before Top
Dead Center
(BTDC)

JOB SHEET #6

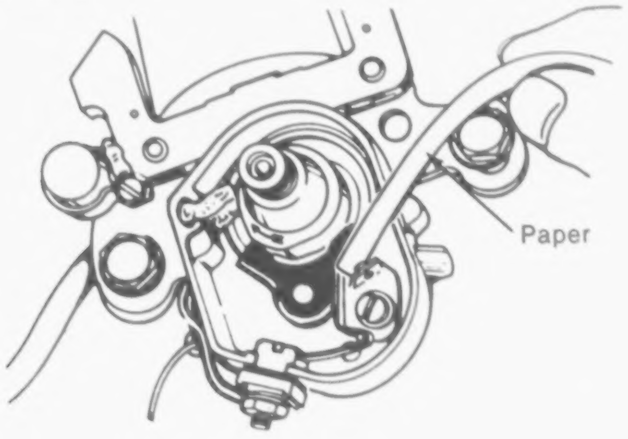
6. If cam has double timing marks, follow the procedure below for correct timing (Figure 4)

FIGURE 4


Rotate Stator To Align Edge Of Rocker Arm With Timing Mark on Cam
Stator Bolt
CAM TOP
CAM TOP
Double Marks
Timing Mark
White Rocker Arm

7. Clean points by pulling lint-free paper between points (Figure 5)

FIGURE 5



8. Replace spark plug, coil wires, cover, flywheel and shroud
9. Return all tools to their proper places

IGNITION SYSTEMS
UNIT II-C

JOB SHEET #7 — TEST CONDENSER FOR LEAKAGE OR SHORT

A. Tools and materials needed

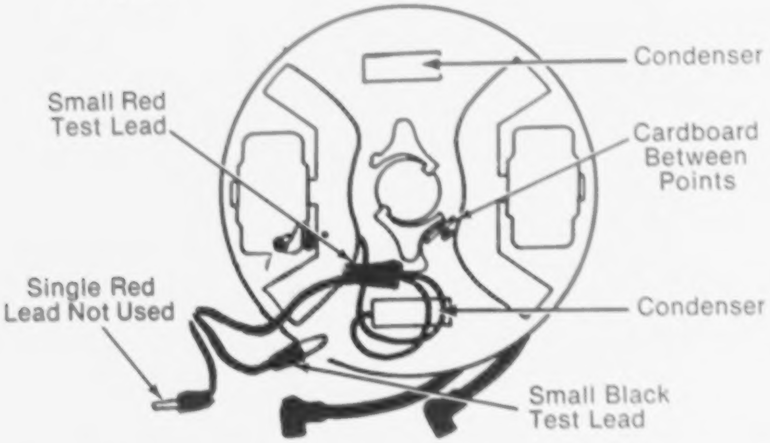
1. Hand tool assortment
2. Ignition Analyzer

   (NOTE: The Merc-O-Tronic Ignition Analyzer is used in this job sheet.)
3. Safety glasses
4. Shop towels

B. Procedure

1. Remove all parts necessary to get at ignition system
2. Read operator's manual and determine correct location of ignition parts and how to make proper connections for testing the condenser (Figure 1)

FIGURE 1


Condenser
Small Red Test Lead
Cardboard Between Points
Single Red Lead Not Used
Condenser
Small Black Test Lead

3. **Connect small black test lead to stator plate if condenser is mounted, otherwise to body of condenser (Figure 1)**
4. **Connect small red test lead to breaker terminal, or if unmounted, to condenser lead (Figure 1)**
5. **Place a piece of cardboard between breaker points (Figure 1)**

JOB SHEET #7

6. To make the condenser test, cord must be plugged into 115 volt 60-cycle AC outlet

7. Turn selector switch to No. 5 "Leakage" and short

8. Degress red button and hold a minimum of 15 seconds; read scale No. 5

9. The meter pointer hand will move to the right and must return within range of the narrow black bar at the left

   (NOTE: Any readings that fall to the right of the black bar indicates the condenser is leaking or shorted and must be replaced

10. Remove all test leads

11. Replace defective condenser

12. Install all other parts on engine

13. Start engine and adjust to recommended specifications

14. Have instructor evaluate work

15. Clean work area and return tools to their proper places

SE - 119-C

IGNITION SYSTEMS
UNIT II-C

NAME ______________________

TEST

1. State the purpose of the ignition system.

____

____

2. Match the types of ignition systems on the right with their correct descriptions.

______a. Produces current by magnetic induction for the primary ignition circuit without any outside source of electricity

______b. Uses semiconductors in place of one or more standard ignition components

______c. Uses electronic parts in place of mechanically operated ignition points

______d. Uses battery to supply source of current for the primary ignition circuit

1. Battery ignition system
2. Magneto ignition system
3. Breakerless ignition system
4. Solid state ignition system

3. Distinguish between the components of the primary and secondary battery ignition circuits by placing a "P" in front of the components in the primary ignition circuit and an "S" in front of those in the secondary ignition circuit.

______a. Resistance unit (resistor)

______b. Condenser

______c. Distributor cap

______d. Ignition switch

______e. Rotor

______f. Secondary winding

______g. High voltage wire

______h. Low voltage wire

______i. Contact points

______j. Battery

______k. Primary winding

______l. Spark plug

TEST

4. Identify the components of a magneto ignition system

a. ____________

b. ____________

c. ____________

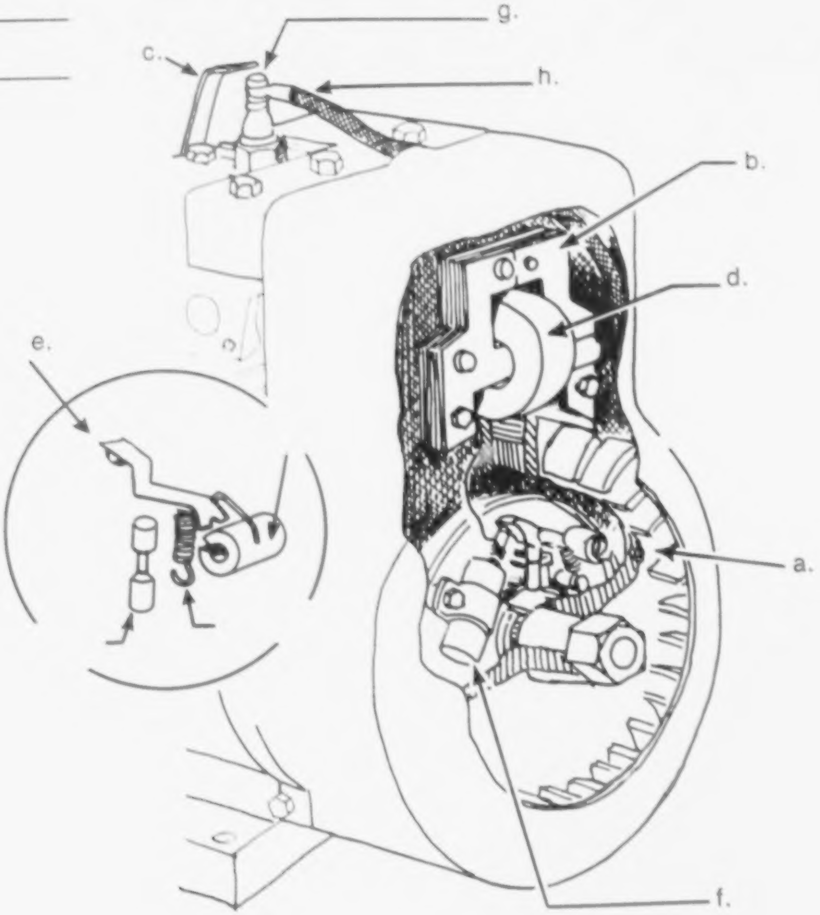
d. ____________

e. ____________

f. ____________

g. ____________

h. ____________



TEST

5. Identify the components of a solid state ignition system.

a. ____________

b. ____________

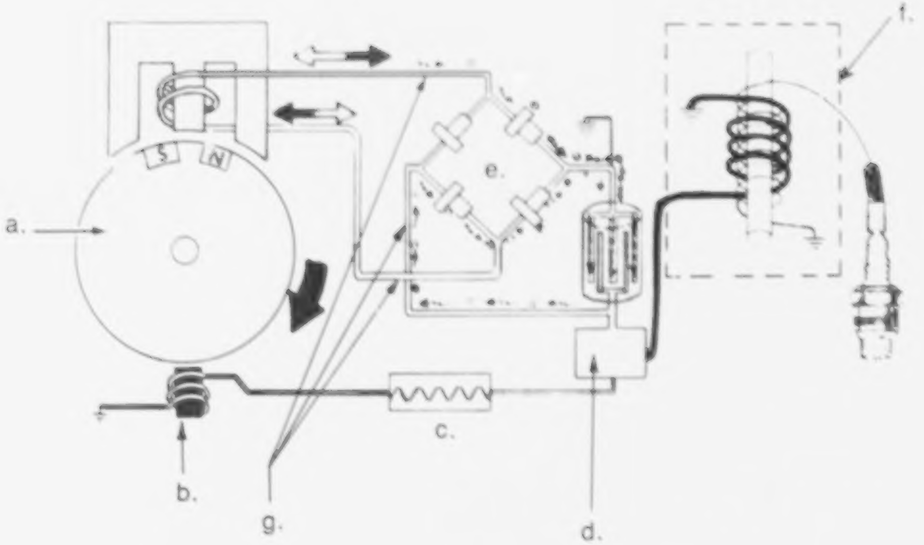
c. ____________

d. ____________

e. ____________

f. ____________

g. ____________



TEST

6. Identify the components of a breakerless ignition system.

a. ____________

b. ____________

c. ____________

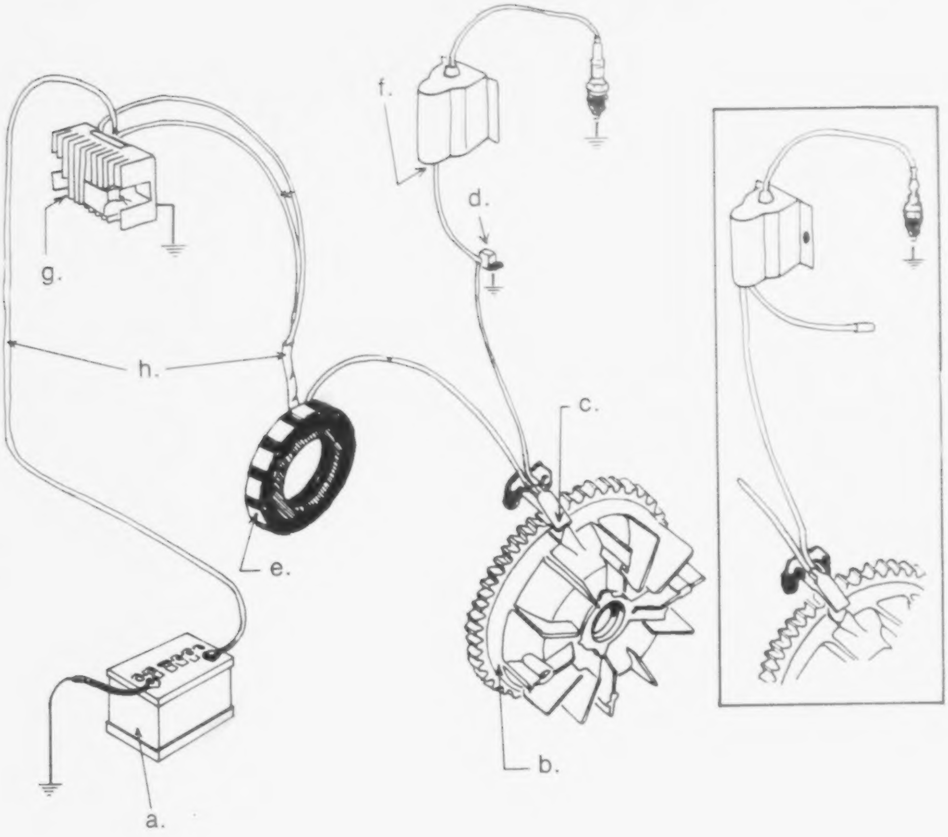
d. ____________

e. ____________

f. ____________

g. ____________

h. ____________



TEST

7. Match the components of the ignition system on the right with their correct purposes.

______a. Source of electrical power

______b. Opens and closes the primary circuit from the battery or coil to the contact points

______c. Transforms low voltage into high voltage necessary to jump the spark plug gap

______d. Make and break the primary circuit to allow the coil to produce high voltage at the spark plug

______e. Stores extra current as the contact points open to prevent arcing and burning

______f. Opens the contact points

______g. Changes alternating (AC) current to direct (DC) current

______h. Used in solid state ignition systems and operates like the condenser

______i. Generates a small amount of current that is used to activate the current from the capacitor

______j. Reduces voltage in the primary circuit to protect the contact points

______k. Provides a spark gap inside the engine cylinder to ignite the fuel-air mixture

______l. Carries low voltage from the battery or armature to the primary side of the ignition coil

______m. Carries high voltage from the secondary side of the coil to the spark plug

1. Trigger coil
2. Spark plug
3. Coil
4. Resistor
5. High voltage wire
6. Breaker cam
7. Battery
8. Diode rectifier
9. Contact points
10. Low voltage wire
11. Ignition switch
12. Capacitor
13. Condenser

TEST

8. Distinguish between the operational steps of the ignition systems by placing an "X" under the appropriate system heading.

	Battery	Magneto	Solid State	
a.	______	______	______	With the ignition switch on and the contact points closed, low voltage current flows from the battery through the primary windings of the coil and through the contact points to ground
b.	______	______	______	With the ignition switch on or the contact points closed, low voltage current is induced by magnets through the primary windings of the coil and through the contact points to ground
c.	______	______	______	With the ignition switch on, low voltage current from the flywheel magnet induces alternating current (AC) in charge coil
d.	______	______	______	The flow of low voltage current through the primary windings of the coil causes a magnetic field buildup
e.	______	______	______	The AC current passes through a rectifier and changes to direct current (DC), which travels to the capacitor (condenser) where it is stored
f.	______	______	______	As the contact points open, current attempts to continue to flow across the point surfaces; the condenser attached to the points absorbs this flow of current
g.	______	______	______	The flywheel magnets pass the trigger coil and induce a small electrical charge, which turns on the silicon controlled rectifier (SCR)
h.	______	______	______	Stopping the flow of current causes the magnetic field of the coil to collapse across the secondary coil windings, causing a high voltage surge
i.	______	______	______	The high voltage surge is directed from the secondary windings of the coil through the distributor cap and rotor and on to the spark plug to ground

TEST

j. ______ ______ ______ The high voltage surge is directed from the secondary windings of the coil through the secondary wire on to the spark plug to ground

k. ______ ______ ______ The instantaneous discharge of energy induces a very high density magnetic field around the primary winding of the coil, which cuts the secondary winding and thus creates sufficient energy to fire the spark plug

9. Demonstrate the ability to:

   a. Remove, service, and replace spark plugs (Job Sheet #1).

   b. Remove and replace contact points and condenser (Job Sheet #2).

   c. Test the coil, condenser, armature, and flywheel magnets (Job Sheet #3).

   d. Test and adjust a solid state ignition system (Job Sheet #4).

   e. Perform a coil power test (Job Sheet #5).

   f. Check ignition timing using a dial indicator (Job Sheet #6).

   g. Test condenser for leakage or short (Job Sheet #7).

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

IGNITION SYSTEMS
UNIT II-C

ANSWERS TO TEST

1. Produces high voltage current to ignite the fuel-air mixture in the engine cylinder

2. a. 2
   b. 4
   c. 3
   d. 1

3. a. P
   b. P
   c. S
   d. P
   e. S
   f. S
   g. S
   h. P
   i. P
   j. P
   k. P
   l. S

4. a. Flywheel with magnets
   b. Armature
   c. Switch stop
   d. Coil
   e. Contact points
   f. Condenser
   g. Spark plug
   h. High voltage wire

5. a. Flywheel with magnets
   b. Trigger coil
   c. Resistor
   d. Transistorized rectifier (solid state switch)
   e. Diode rectifier
   f. Ignition coil
   g. Low voltage wire

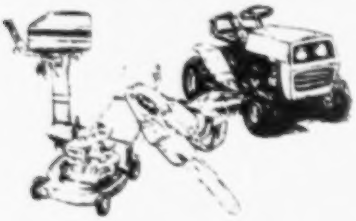
6. a. Battery
   b. Flywheel
   c. Trigger module
   d. Ignition switch
   e. Alternator-stator
   f. Ignition coil assembly
   g. Rectifier-regulator
   h. Low voltage wire

7. a. 7
   b. 11
   c. 3
   d. 9
   e. 13
   f. 6
   g. 8
   h. 12
   i. 10
   j. 4
   k. 2
   l. 10
   m. 5

ANSWERS TO TEST

8. a. Battery
   b. Magneto
   c. Solid State
   d. Battery, Magneto
   e. Solid State
   f. Battery, Magneto
   g. Solid State
   h. Battery, Magneto
   i. Battery
   j. Magneto
   k. Solid State

9. Performance skills evaluated according to standards identified by the instructor



Charging Systems
Unit III-C

UNIT OBJECTIVE

After completion of this unit, the student should be able to remove and replace, disassemble, check, and reassemble an alternator. Competencies will be demonstrated by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to the charging system with their correct definitions.
2. List two kinds of charging systems.
3. Match charging system components with their correct functions.
4. Match operating stages of the charging system with their correct functions.
5. Complete a list of statements concerning how a generator converts AC to DC
6. Identify the parts of the alternator system.
7. List two advantages of an alternator over a generator.
8. Select true statements concerning reverse polarity.
9. Demonstrate the ability to:
    a. Remove and replace an alternator (Job Sheet #1).
    b. Disassemble, check, and reassemble an alternator (Job Sheet #2).

CHARGING SYSTEMS
UNIT III-C

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Integrate the following activities throughout the teaching of this unit:

1. Demonstrate and discuss the procedures outlined in the job sheets.
2. Provide examples of alternators and generators if space permits, or show illustrations to class.
3. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

SUGGESTED ACTIVITIES

C. Information sheet

D. Transparency masters

1. TM 1 — Charging System Components
2. TM 2 — How AC Converts to DC
3. TM 3 — Parts of the Alternator Charging System

E. Job sheets

1. Job Sheet #1 — Remove and Replace an Alternator
2. Job Sheet #2 — Disassemble, Check, and Reassemble an Alternator

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Small Engines Volume 1 and 2.* Athens, Georgia: American Association for Vocational Instructional Materials, 1974.

B. Armstrong, Ivan. *Auto Mechanics, Volume 1.* Stillwater, Oklahoma: Oklahoma State Department of Vocational and Technical Education, 1976.

C. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

CHARGING SYSTEMS
UNIT III-C

INFORMATION SHEET

I. **Terms and definitions**

A. Charging system — Recharges the battery and maintains a supply of electrical current to meet the operating needs of the engine and auxillary circuits

B. Amp — Unit of measurement for electrical current

C. Volt — Unit of electrical pressure or force that will move a current of one ampere through a resistance of one ohm

D. Ohm — Standard unit for measuring resistance to flow of electrical current

E. Diode (rectifier) — Device that will allow current through itself in one direction and will block current in the opposite direction

F. Short circuit — Wire touching another wire and providing a shorter path for current to flow

G. Open circuit — Circuit in which a wire is broken or disconnected

H. Grounded circuit — Circuit in which a wire touches ground causing the current to flow to ground instead of through the circuit

I. Armature — Series of wire conductors in the form of a loop rotating in a stationary magnetic field

J. Commutator — Bars on end of armature drive shaft and connected to the ends of each wire conductor wound on armature

K. Pole shoes — Permanent magnets that are fixed to the inside of the generator housing and set opposite each other to create a weak magnetic field

L. Field circuit — One wire conductor wound around both poles many times and attached to the brush

M. Regulator — Assembly which houses the cut-out relay, voltage regulator, and current regulator

N. Arcing — Current attempting to cross between the commutator sections and the brush

O. Polarity — Direction of current flow through the generator

(NOTE: Generator circuits need to be polarized after servicing.)

INFORMATION SHEET

P. "A" circuit — Regulator circuit with supply voltage to the generator field, then through the regulator to ground

Q. "B" circuit — Regulator is between the battery and generator field windings

II. **Kinds of charging systems**

(NOTE: Both circuits generate an alternating current, but differ in how they rectify the alternating current to direct current.)

A. Direct current

(NOTE: Direct current charging systems are associated with generator type systems.)

B. Alternating current

(NOTE: Alternating current charging systems are associated with alternator type systems.)

III. **Charging system components and functions (Transparency 1)**

A. Battery

1. Starts the circuit by supplying spark to start engine

2. Helps out during peak operation when electrical loads are too much for generator or alternator

B. Generator or alternator

1. Supplies electrical power to accessory circuits

2. Recharges battery

C. Regulator

1. Opens and closes the charging circuit (cut-out relay)

2. Prevents overcharging of battery (voltage regulator)

3. Limits the generator's output to safe rates (current regulator)

D. Ammeter — Measures the rate of current flow

IV. **Operating stages of charging system**

A. Starting — Battery supplies all load current

B. Peak operation — Battery helps generator supply current

C. Normal operation — Generator supplies all current and recharges battery

INFORMATION SHEET

V. **How a generator converts AC to DC (Transparency 2)**

A. Commutator is split in two parts creating a gap as the commutator passes the brushes

(NOTE: This is called the static neutral point where no voltage is created.)

B. Past this point the other half of the commutator contacts the brushes reversing the current flow

C. At the same time the rotating armature reverses its polarity converting AC to DC

VI. **Parts of the alternator system (Transparency 3)**

A. Alternator coil (stator)

B. Flywheel

C. Ceramic ring

D. Rectifier

E. Battery

VII. **Advantages of an alternator over a generator**

A. Produces higher output at low and idle engine speeds

B. Provides simplicity in construction which requires less maintenance

VIII. **Reverse polarity**

A. Generator polarity is opposite that of the battery

B. Battery is in series with the generator

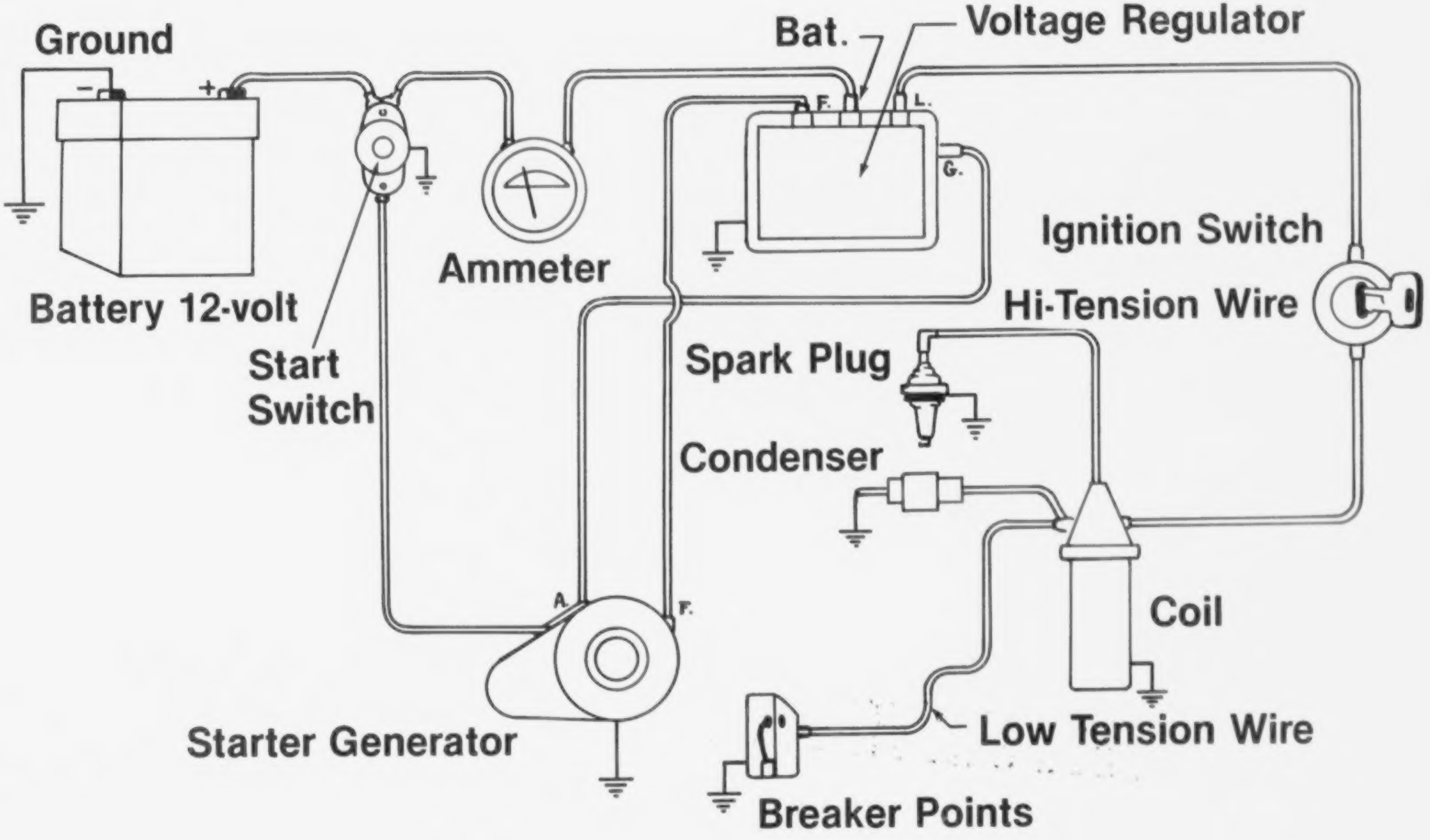
C. Generator builds up voltage and closes the cut-out relay points

D. High voltage can create enough current and heat to weld the points together

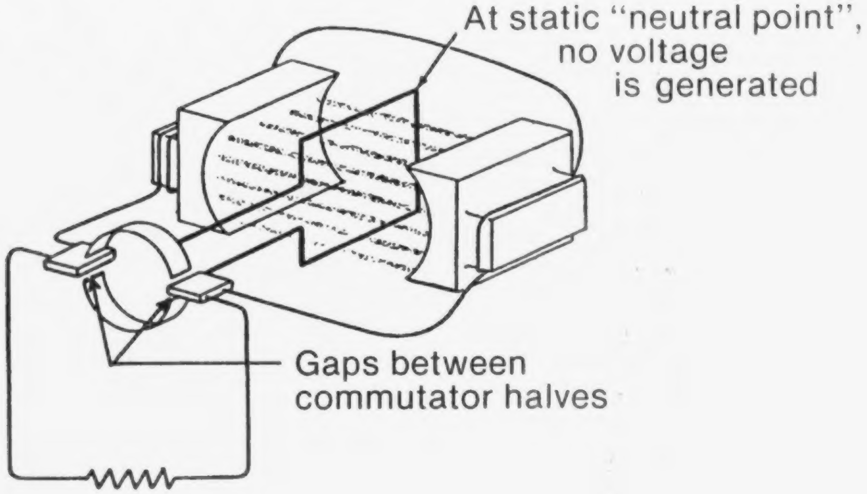
(CAUTION: After any service, polarize the DC generator.)

(NOTE: Pole shoe polarity is determined by the magnetism of the field coils the last time current passed through the coils; a slight current through the field coils when servicing can accidentally change pole polarity.)

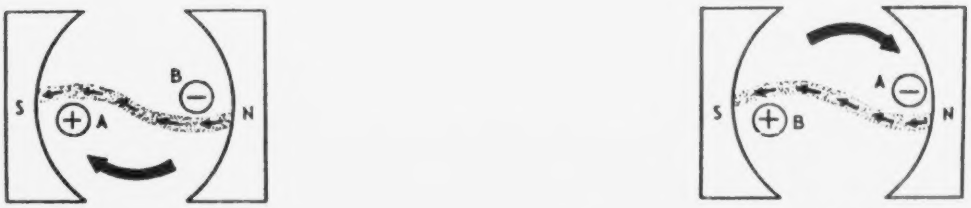
Charging System Components


Ground
Bat.
F.
L.
Voltage Regulator
G.
Battery 12-volt
Start Switch
Ammeter
Ignition Switch
Hi-Tension Wire
Spark Plug
Condenser
A.
F.
Coil
Starter Generator
Low Tension Wire
Breaker Points

How AC Converts To DC


At static "neutral point", no voltage is generated
Gaps between commutator halves

How Generator Converts AC To DC current

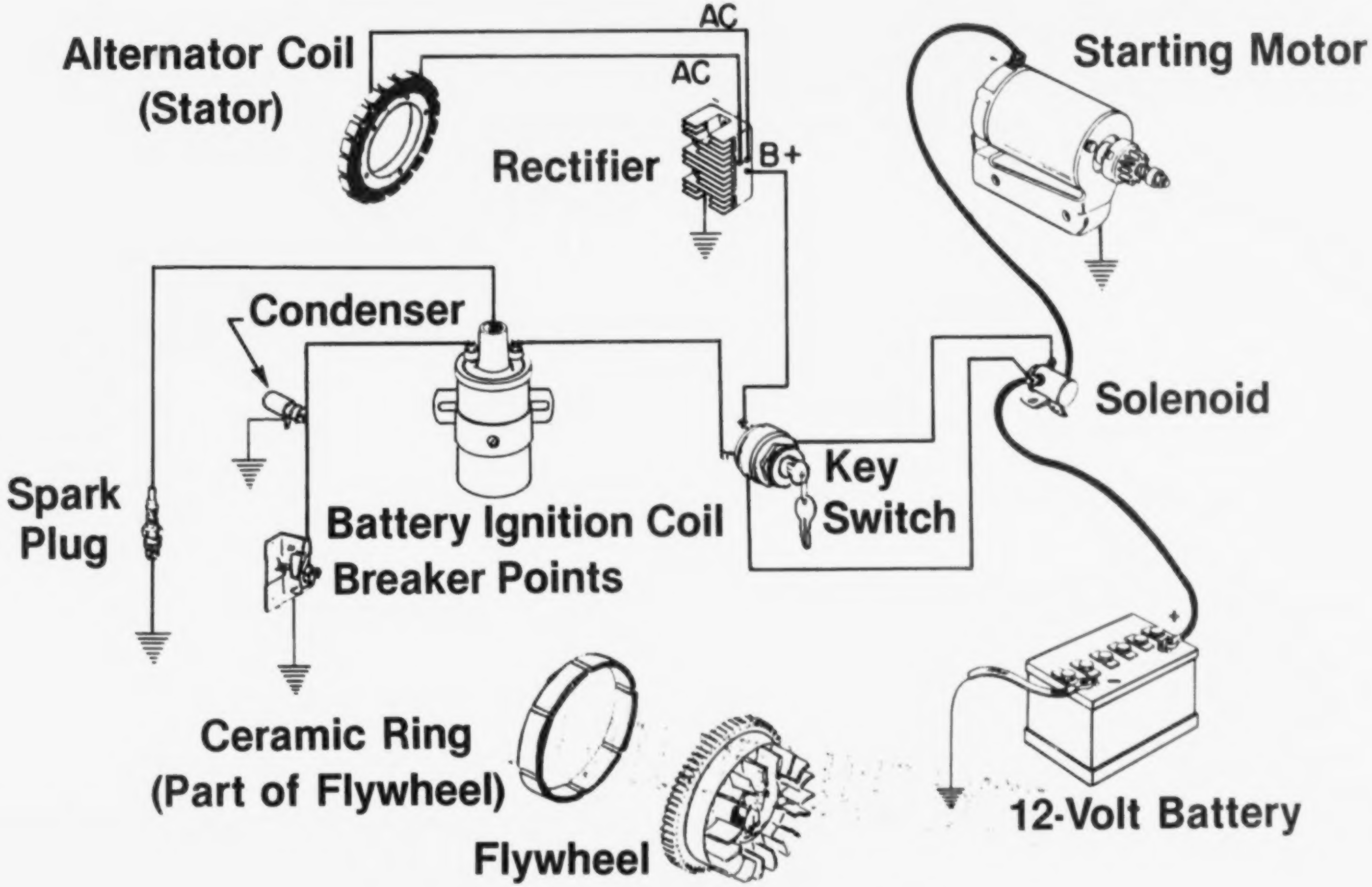


First Half of Revolution

Second Half of Revolution

How the Polarity of the Armature Changes During Each Revolution

Parts of the Alternator Charging System


AC
Alternator Coil (Stator)
AC
Starting Motor
Rectifier
B+
Condenser
Solenoid
Key Switch
Spark Plug
Battery Ignition Coil
Breaker Points
Ceramic Ring (Part of Flywheel)
12-Volt Battery
Flywheel

403

404

CHARGING SYSTEMS
UNIT III-C

JOB SHEET #1 — REMOVE AND REPLACE AN ALTERNATOR

A. Tools and materials needed

1. Hand tool assortment
2. Flywheel removal tools
3. Shop towels
4. Safety glasses

B. Procedure

1. Remove engine shroud or blower housing
2. Remove flywheel

   (NOTE: Check magnets on flywheel for small metal chips and remove them.)
3. Check correct location of stator wires
4. Remove stator bolts and spacers
5. Remove rectifier bolt
6. Remove stator and rectifier as a unit
7. Replace rectifier
8. Replace stator

   (NOTE: Hold stator toward screws to take up clearance in mounting bushing.)
9. Install flywheel

   (NOTE: Check stator wire location so they do not rub the flywheel.)
10. Replace blower housing
11. Start engine and check alternator output

CHARGING SYSTEMS
UNIT III-C

JOB SHEET #2 — DISASSEMBLE, CHECK AND REASSEMBLE AN ALTERNATOR

A. Tools and materials needed

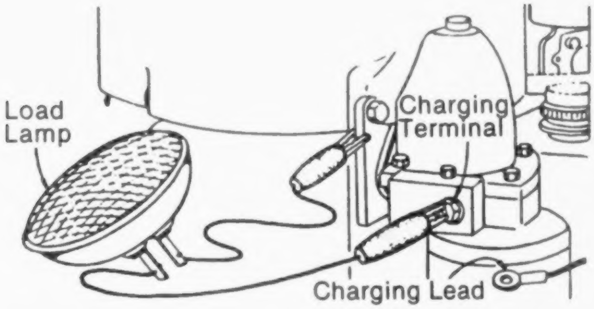
1. Hand tool assortment
2. Ammeter
3. Test lamp
4. Flywheel removal tools
5. Safety glasses

B. Procedure

1. Run tests

   a. Test output (Figure 1)

FIGURE 1



1) Disconnect charging lead from charging terminal

(NOTE: Do not allow terminal on charging lead to touch engine or equipment.)

2) Clip 12-volt load lamp between charging terminal and ground

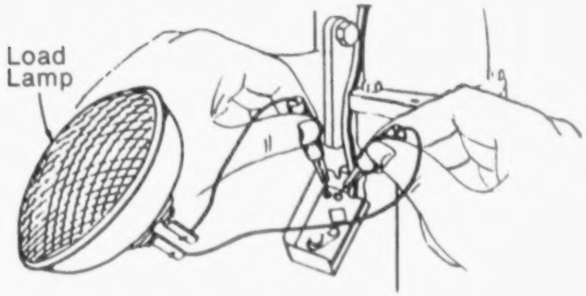
3) Start engine

(NOTE: If lamp lights, alternator is functioning; if lamp does not light, alternator is defective.)

JOB SHEET #2

b. Test stator (Figure 2)

FIGURE 2



1) Disconnect charging lead from battery and rectifier

2) Remove rectifier box mounting screw

3) Rotate box to expose eyelets to which red and black stator leads are soldered

(NOTE: Charging lead terminal must not touch engine.)

4) Start engine

5) Touch load lamp leads to eyelets with engine running

(NOTE: If load lamp lights, the stator is satisfactory; if load lamp does not light, stator or flywheel is defective.)

c. Check flywheel and stator

1) Remove blower housing and flywheel and check to be sure magnet ring is in place and has magnetism

(NOTE: Replace flywheel if needed.)

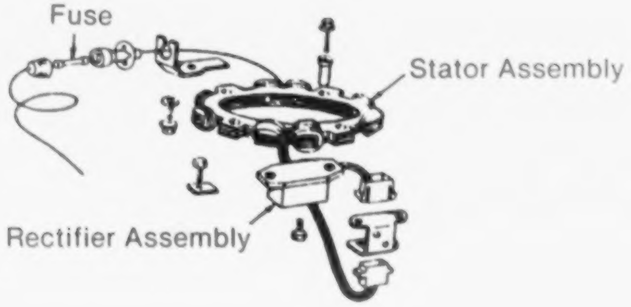
2) Check charging lead to be sure there is a good connection to the positive (+) battery terminal

3) If flywheel or charging lead are not defective, replace stator

JOB SHEET #2

d. Replace defective stator (Figure 3)

FIGURE 3


Fuse
Stator Assembly
Rectifier Assembly

1) Remove flywheel

(NOTE: Be sure to note correct location of stator wires.)

2) Remove two stator mounting screws and bushings

3) Remove rectifier box from stator assembly

4) Install stator

5) Torque screws to correct specifications

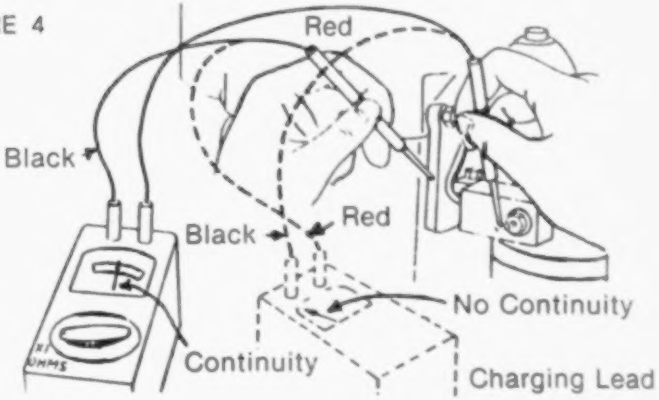
6) Install rectifier box connecting leads correctly

7) Replace flywheel and blower housing and run engine to check output

2. Test system

a. Test half-wave rectifier (Figure 4)

FIGURE 4


Red
Black
Black
Red
No Continuity
Continuity
Charging Lead
X1
OHMS

JOB SHEET #2

1) Do not run engine

2) Use a multimeter to test resistance from charging terminal to ground

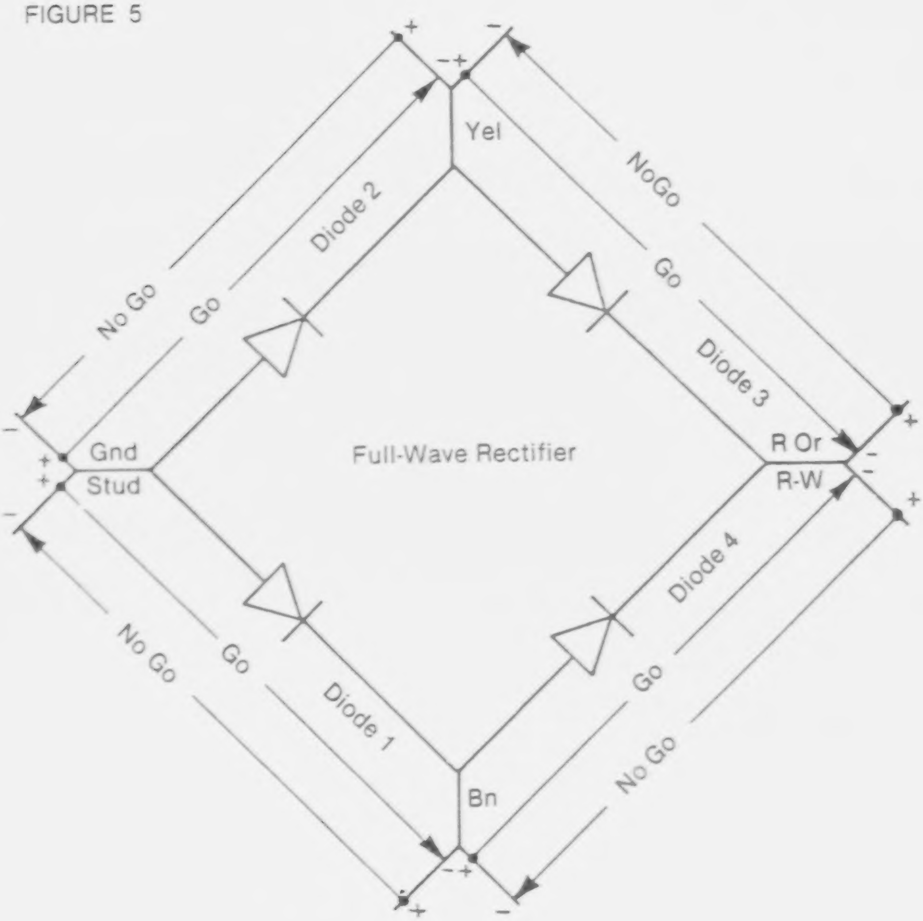
3) Reverse test leads and recheck

(NOTE: One way there should be a meter reading and the other way there should not be a meter reading. The actual meter readings are not important. If the meter shows a reading both ways or neither way, then the rectifier is defective.)

b. Bench test full-wave rectifier with ohmmeter

(NOTE: The bridge or full-wave rectifier consists of 4 diodes, and each one must be tested individually. See Figure 5.)

FIGURE 5


+
−
− +
Yel
NoGo
Diode 2
Go
No Go
Go
Diode 3
+
R Or
−
−
R-W
+
−
+
+
Gnd
Stud
−
Full-Wave Rectifier
Diode 4
No Go
Go
Go
Diode 1
No Go
Bn
− +
+
−

JOB SHEET #2

1) Connect the positive (+) lead of the ohmmeter to the ground stud and the negative (-) lead of the ohmmeter to the brown (common) terminal on diode #1

   (NOTE: The meter should show a low resistance, meaning the current will flow ("GO") in that direction.)

2) Reverse the ohmmeter leads, negative (-) lead to the ground stud and positive (+) lead to the brown (common) terminal on diode #1

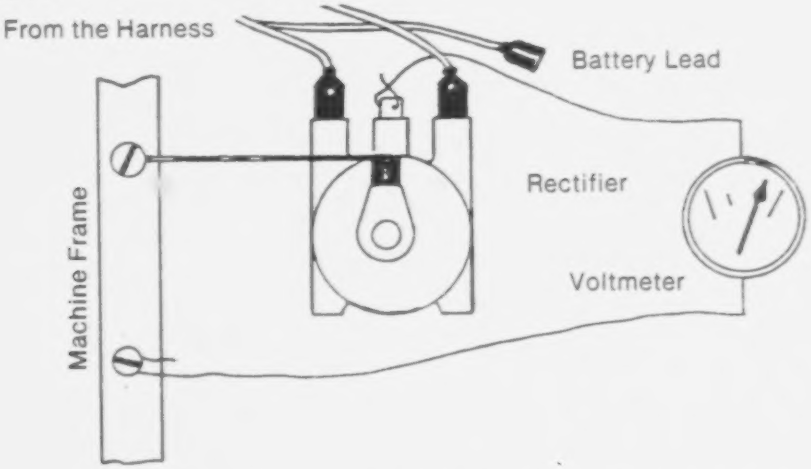
   (NOTE: There should be a very high resistance reading, meaning current will not flow ("NO GO") in that direction; a low or high resistance reading in both directions indicates a faulty rectifier.)

3) Repeat the procedure for each of the remaining diodes

   (NOTE: Since color coding varies with different makes and models, the appropriate service manual should be consulted to identify the rectifier terminals.)

c. Test full-wave rectifier with voltmeter (Figure 6)

FIGURE 6



1) Disconnect the rectifier to battery lead at the rectifier terminal

2) Connect the voltmeter from the rectifier terminal to a good ground

3) Start the engine and increase the speed to approximately 3,000 RPM

   (NOTE: The voltmeter should read about 7 volts for a 6-volt system and 14 volts for 12-volt system; a low reading indicates a faulty rectifier.)

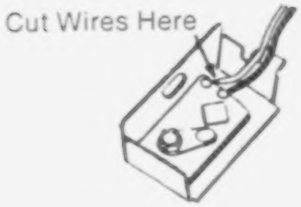
JOB SHEET #2

d. Replace defective half-wave rectifier (Figure 7)

1) Remove rectifier from engine or starter motor

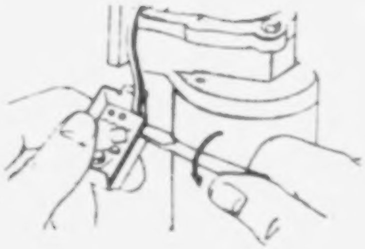
2) Pry off fiber board exposing soldered connections between rectifier and stator leads (Figure 7)

FIGURE 7


Cut Wires Here

3) Cut stator leads close to eyelets (Figure 8)

FIGURE 8



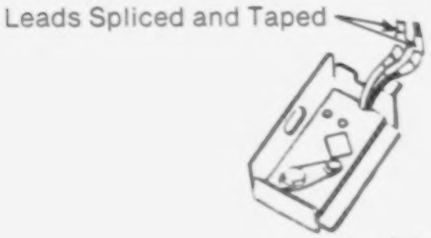
4) Strip insulation back 3/8" on stator leads

5) Discard defective rectifier box

6) Solder on new rectifier leads to stator leads

7) Wrap solder and splices carefully with tape (Figure 9)

FIGURE 9


Leads Spliced and Taped

JOB SHEET #2

8) Fold leads into rectifier box and mount on starter or engine (Figures 10 and 11)

(**NOTE**: Wires should not rub on flywheel.)

FIGURE 10

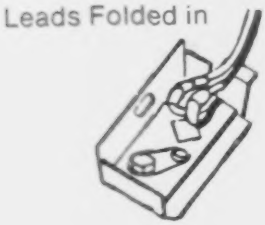
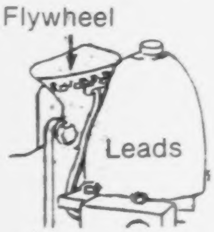

Leads Folded in

FIGURE 11


Flywheel
Leads

9) Install flywheel and blower housing

10) Check output

CHARGING SYSTEMS
UNIT III-C

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

______a. Unit of measurement for electrical current

______b. Unit of electrical pressure or force that will move a current of one ampere through a resistance of one ohm

______c. Standard unit for measuring resistance to flow of electrical current

______d. Device that will allow current through itself in one direction and will block current in the opposite direction

______e. Wire touching another wire and providing a shorter path for current to flow

______f. Circuit in which a wire is broken or disconnected

______g. Circuit in which a wire touches ground causing the current to flow to ground instead of through the circuit

______h. Recharges the battery and maintains a supply of electrical current to meet the operating needs of the engine and auxiliary circuits

______i. Current attempting to cross between the commutator sections and the brush

______j. Series of wire conductors in the form of a loop rotating in a stationary magnetic field

______k. Regulator is between the battery and generator field windings

1. Open circuit
2. Arcing
3. Ohm
4. "A" Circuit
5. Charging system
6. Armature
7. Grounded circuit
8. Commutator
9. Short circuit
10. Pole shoes
11. Diode (rectifier)

TEST

_____l. Permanent magnets that are fixed to the inside of the generator housing and set opposite each other to create a weak magnetic field

_____m. Assembly which houses the cut-out relay, voltage regulator, and current regulator

_____n. Direction of current flow through the generator

_____o. One wire conductor wound around both poles many times and attached to the brush

_____p. Bars on end of armature drive shaft and connected to the ends of each wire conductor wound in armature

_____q. Regulator circuit with supply voltage to the generator field, then through the regulator to ground

12. Field circuit
13. Volt
14. Polarity
15. Amp
16. "B" Circuit
17. Regulator

2. List two kinds of charging systems.

a. ____

b. ____

3. Match the charging system components on the right with their correct functions.

_____a. Supplies electrical power to accessory circuits and recharges battery

_____b. Measures the rate of current flow

_____c. Opens and closes the charging circuit (cut-out relay), prevents overcharging of battery (voltage regulator), and limits the generator's output to safe rates current regulator)

_____d. Starts the circuits by supplying spark to start engine and helps out during peak operation when electrical loads are too much for generator or alternator

1. Regulator
2. Ammeter
3. Battery
4. Generator or alternator

TEST

4. Match the operating stages of the charging system on the right with their correct functions.

______a. Battery helps generator supply current

______b. Generator supplies all current and recharges battery

______c. Battery supplies all load current

1. Starting
2. Peak operation
3. Normal operation

5. Complete the following list of statements concerning how a generator converts AC to DC by correctly filling in the blanks.

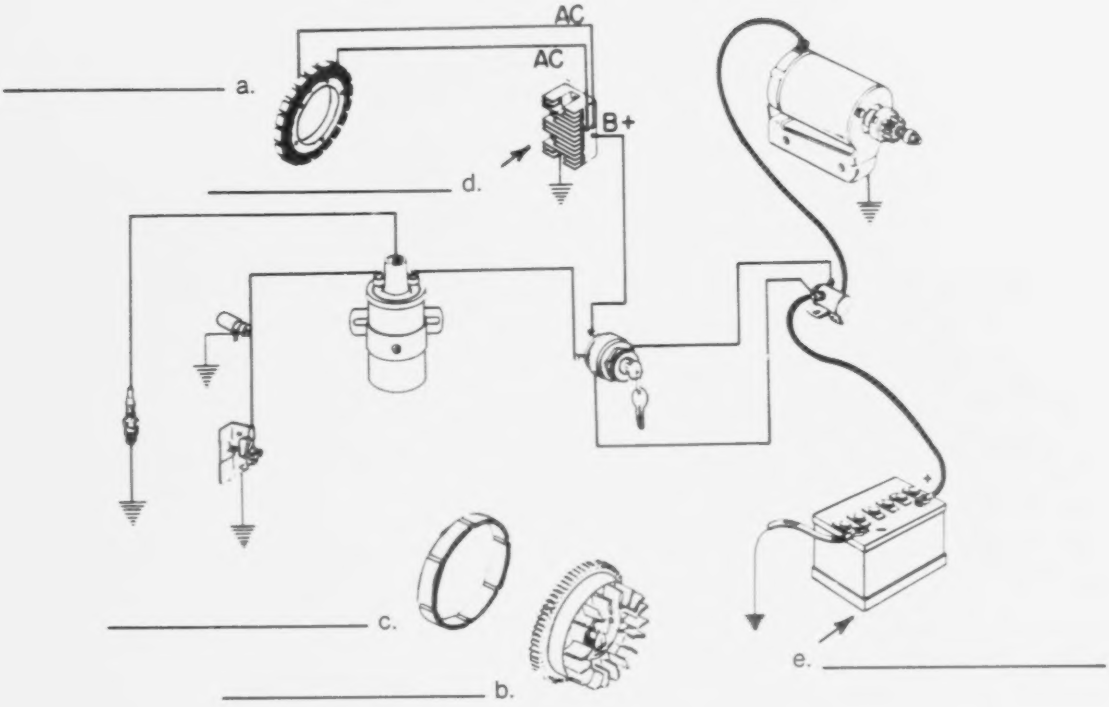
   a. Commutator is split in two parts creating a gap as the commutator passes the ______________________

   b. Past this point the other half of the commutator contacts the brushes ______________________ the current flow

   c. At the same time the rotating armature reverses its ______________________ converting AC to DC

TEST

6. Identify the parts of the alternator system.



7. List two advantages of an alternator over a generator.

a. ______________________________

b. ______________________________

8. Select true statements concerning reverse polarity by placing an "X" in the appropriate blanks.

_____a. Generator polarity is opposite that of the battery

_____b. Battery is in series with the alternator

_____c. Generator builds up voltage and closes the cut-out relay points

_____d. High voltage can create enough current and heat to weld the points together

TEST

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

9. Demonstrate the ability to:
   a. Remove and replace an alternator (Job Sheet #1).
   b. Disassemble, check, and reassemble an alternator (Job Sheet #2).

CHARGING SYSTEMS
UNIT III-C

ANSWERS TO TEST

1. a. 15
   b. 13
   c. 3
   d. 11
   e. 9
   f. 1
   g. 7
   h. 5
   i. 2
   j. 6
   k. 16
   l. 10
   m. 17
   n. 14
   o. 12
   p. 8
   q. 4

2. a. Direct current
   b. Alternating current

3. a. 4
   b. 2
   c. 1
   d. 3

4. a. 2
   b. 3
   c. 1

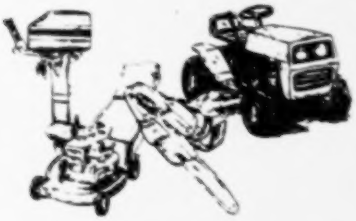
5. a. Brushes
   b. Reversing
   c. Polarity

6. a. Alternator coil (stator)
   b. Flywheel
   c. Ceramic ring
   d. Rectifier
   e. Battery

7. a. Produces higher output at low and idle engine speeds
   b. Provides simplicity in construction which requires less maintenance

8. a,c,d

9. Performance skills evaluated according to the standards identified by the instructor



Starting Systems
Unit IV-C

UNIT OBJECTIVE

After completion of this unit, the student should be able to remove and replace a starter, replace a starter rewind spring, and service a vertical pull starter. Competencies will be demonstrated by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to starting systems with their correct definitions.
2. Identify the types of small gas engine starters.
3. Match components of the mechanical starting system with their correct functions.
4. Match components of the DC starting system with their correct functions.
5. Demonstrate the ability to:
    a. Remove, disassemble, test, service, and reassemble a starter (Job Sheet #1).
    b. Replace starter rewind spring (Job Sheet #2).
    c. Service the vertical pull starter (Job Sheet #3).

STARTING SYSTEMS
UNIT IV-C

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets prior to the demonstration of the procedures.

H. Integrate the following activities throughout the teaching of this unit:

1. Provide examples of different types of starters and starter drives.
2. Identify parts of a twelve-volt starter.
3. Make or obtain a cutaway of a solenoid.
4. Prepare a test board for solenoids to show double pole charging system and to show potential starter problems.
5. Demonstrate and discuss the procedures outlined in the job sheets.
6. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

SUGGESTED ACTIVITIES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

   1. TM 1 — Types of Starters

   2. TM 2 — Types of Starters (Continued)

E. Job sheets

   1. Job Sheet #1 — Remove, Disassemble, Test, Service, and Reassemble a Starter

   2. Job Sheet #2 — Replace Starter Rewind Spring

   3. Job Sheet #3 — Service the Vertical Pull Starter

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Armstrong, Ivan. *Auto Mechanics, Volume I.* Stillwater, Oklahoma. Oklahoma State Department of Vocational and Technical Education, 1976.

B. *Small Engines, Volume II.* Third Edition. Athens, Georgia: American Association for Vocational Instructional Materials, 1974.

C. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

D. Herd, Amon. *Starters Service and Repair* (For Briggs and Stratton Engines). Columbia, Missouri: Instructional Materials Laboratory, University of Missouri.

STARTING SYSTEMS
UNIT IV-C

INFORMATION SHEET

I. **Terms and definitions**

A. Starter — Device which converts mechanical or electrical power into rotating motion for cranking engine

B. Starter frame — Housing which connects and contains starter component parts

C. Armature — Main shaft in starter, composed of commutator segments, windings, and bushing or bearing journals

D. Brushes — Sliding contacts which transfer electrical energy to commutator

E. Starter drive pinion — Gear that meshes with flywheel to crank engine

F. Pole shoes — Ends of magnets in the field frame of a starting motor

G. Field coils — Wire wrapped around pole pieces to increase the strength of the magnetic field when current is applied

H. Safe interlock (neutral interlock) — Safety device which allows engine to be started in neutral only

I. Solenoid — Electromagnetic device which produces a reciprocating motion for remote control of starting circuit

II. **Types of small gas engine starters (Transparencies 1 and 2)**

A. Rope-wind

B. Rope-rewind

C. Vertical pull

D. Electric (AC and DC)

III. **Components of mechanical starting system**

A. Starter housing — Cover for the starter mechanism

B. Recoil spring — Used to automatically rewind the starter rope after each starting attempt

C. Pulley — Housing for pawls that lock to crankshaft adapter to crank engine

INFORMATION SHEET

D. Engaging pawl — Locks pulley to crankshaft adapter on starting pull of rope

E. Pawl spring — Returns pawl to neutral position during rewind cycle

IV. **Components of DC starting system**

A. Battery — Source of electrical power

B. Key switch — Device which activates the starter motor switch

C. Starter motor switch — Switch which closes the high amperage circuit from battery to starter

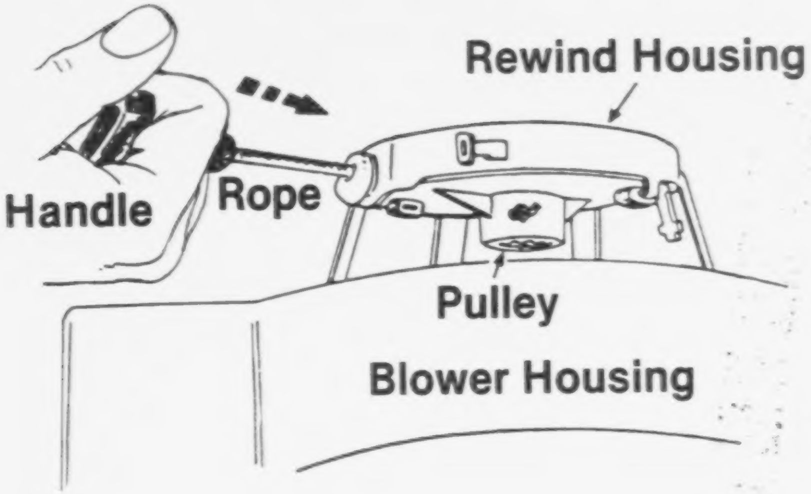
D. Starter motor — Drives the flywheel to crank the engine

E. Switch wire — Conductor that carries a low amount of current to energize the starter motor switch

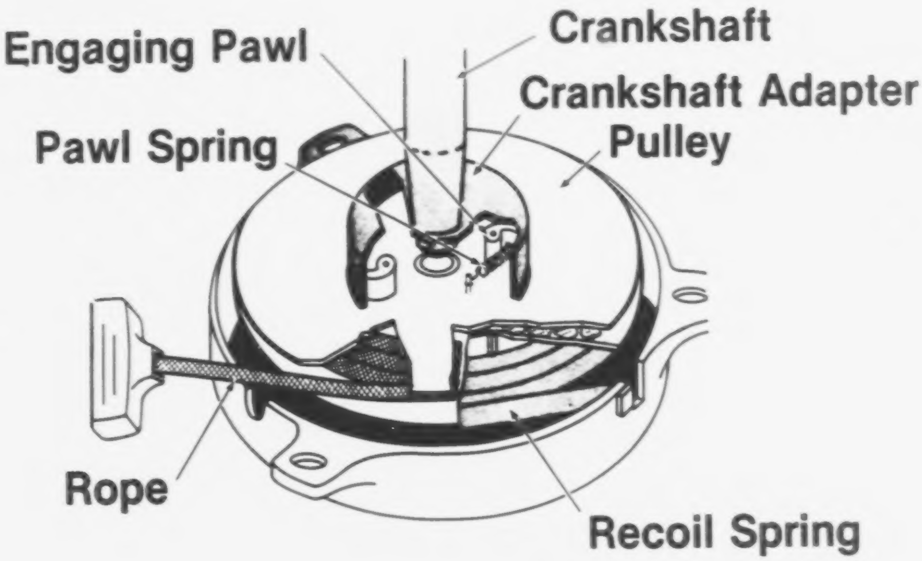
F. Battery cables — Conductors which carry large amounts of current to complete the starter circuit

Types of Starters

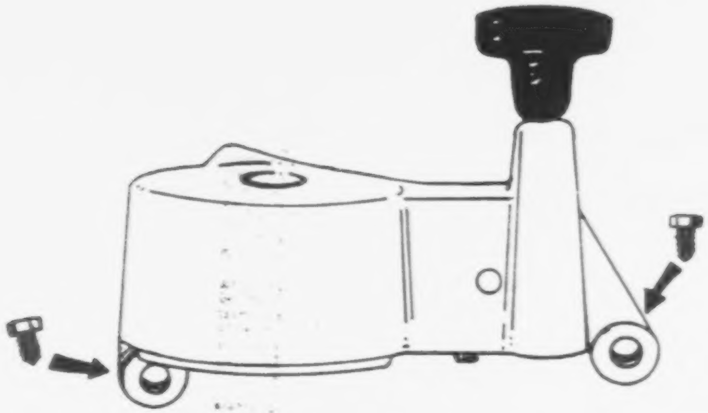
Rope Wind


Rewind Housing
Handle
Rope
Pulley
Blower Housing

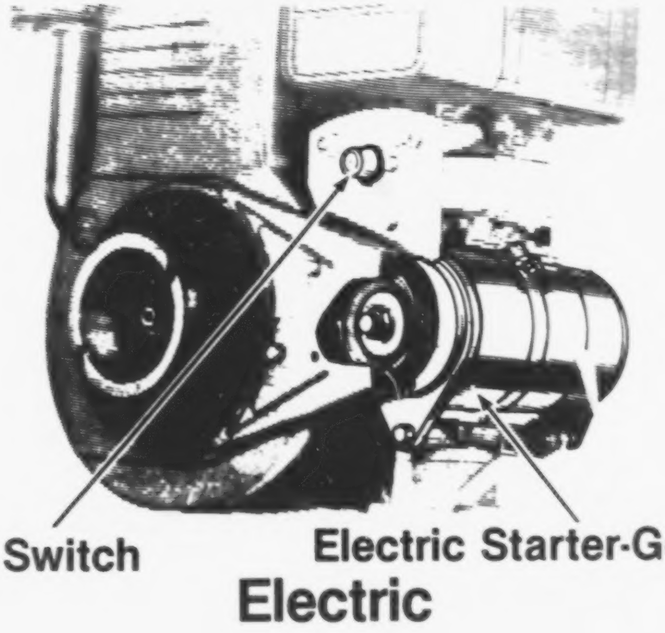
Rope Rewind


Engaging Pawl
Crankshaft
Crankshaft Adapter
Pawl Spring
Pulley
Rope
Recoil Spring

Types of Starters (Continued)



Vertical Pull



Starter Switch
Electric Starter-Generator

Electric

STARTING SYSTEMS
UNIT IV-C

JOB SHEET #1 — REMOVE, DISASSEMBLE, TEST, SERVICE, REASSEMBLE, AND REPLACE A DC STARTER

A. Tools and materials needed

1. Hand tool assortment
2. Armature grounder and test light
3. Solvent and parts brush or rag
4. Ignition wrench set
5. Awl
6. Safety glasses

B. Procedure

1. Remove starter
    a. Disconnect battery ground cable
    b. Remove cables and electrical wires from starter

    (CAUTION: Use two wrenches on terminals when removing top nut to prevent twisting terminal.)

    (NOTE: Carefully identify location of wires with masking tape.)

    c. Remove starter mounting bolts as required
    d. Remove starter brackets and shields as required
    e. Remove starter from engine
2. Disassemble starter
    a. Clean outside case with solvent and brush or rag

    (NOTE: Do not use excessive amounts or submerge starter in solvent. Solvent should not be allowed to enter the starter.)

    b. Scribe mating surfaces for reassembly
    c. Remove thru bolts
    d. Remove end cap

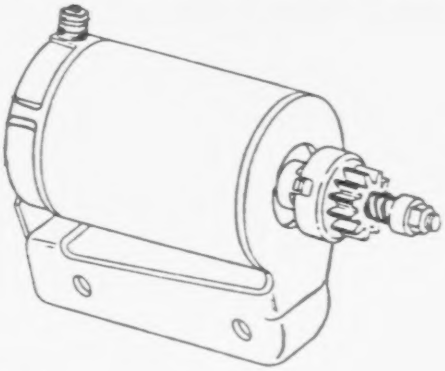
JOB SHEET #1

e. Lift spring and release brush from end cap

f. Remove front plate with armature

(NOTE: Some models may have starter mounting attached to front plate. See Figure 1.)

FIGURE 1

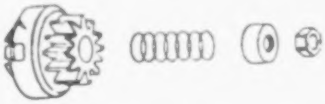


g. Place armature in vise

(NOTE: Be sure to use wooden blocks or jaw protectors on the vise to keep from damaging armature.)

h. Disassemble drive assembly (Figure 2)

FIGURE 2



1) Remove stop nut

2) Separate spring, washers, and drive pinion

(NOTE: Be sure to note location of thrust washers on armature shaft if used.)

3. Test and service

a. Clean all starter components

(NOTE: Clean all parts by wiping with clean cloths. The armature, field coils, and starter drive assembly must not be washed in solvent.)

b. Arrange all starter components for inspection

c. Inspect starter bushings for looseness and replace as required

JOB SHEET #1

d. Inspect starter brushes for wear

(NOTE: Brushes worn to half their original length or less should be replaced.)

e. Inspect the starter drive

(NOTE: The starter drive pinion gear should turn freely in one direction and lock when turned slowly in the other direction.)

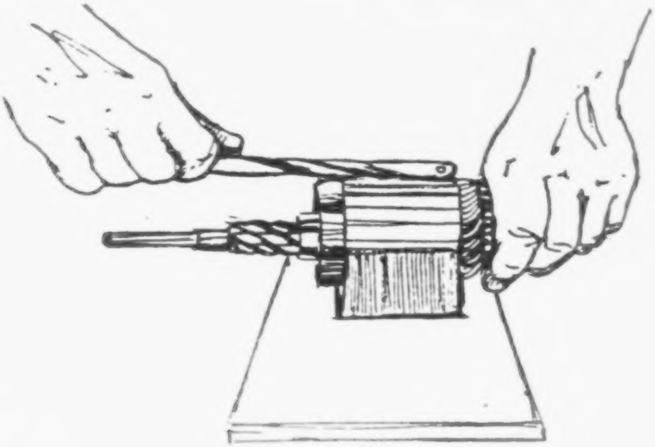
f. Inspect armature commutator

(NOTE: If the armature commutator is rough or out-of-round it should be turned down using suitable equipment.)

g. Test the armature for short circuits (Figure 3)

(NOTE: Place the armature on a growler and rotate the armature while holding a hacksaw blade over the armature core. If the blade vibrates, the armature is shorted and will require replacement.)

FIGURE 3

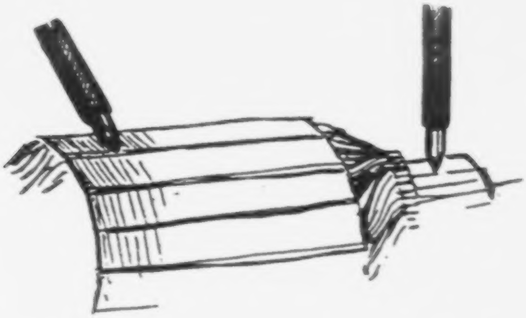


JOB SHEET #1

h. Check armature for ground (Figure 4)

(NOTE: Place one lead of a test lamp on the armature core or shaft and the other on the commutator. If the lamp lights, the armature is grounded and will require replacement.)

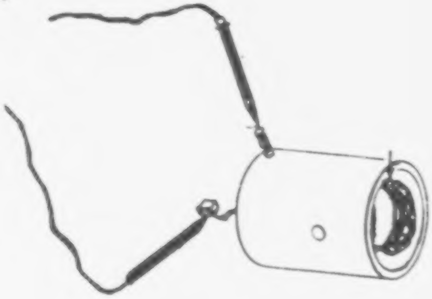
FIGURE 4



i. Check field coil for open circuit (Figure 5)

(NOTE: Place one lead of the test lamp on the insulated brush and the other on the field connection tab. If the lamp does not light, the field coil is open and will require replacement.)

FIGURE 5



j. Replace worn or damaged parts

JOB SHEET #1

4. Reassemble starter
   - a. Place front plate back on armature

     (NOTE: Be sure and replace thrust washers if used.)
   - b. Replace drive assembly

     (NOTE: Torque stop nut to manufacturer's specifications.)
   - c. Lift spring and reinstall brush in end cap
   - d. Place end cap on starter
   - e. Line up scribe marks
   - f. Install thru bolts

     (NOTE: Torque to manufacturer's specifications.)
5. Replace starter
   - a. Clean starter mounting surfaces
   - b. Position starter in mounting position and start bolts
   - c. Tighten mounting bolts securely
   - d. Place all wire and cables on correct terminals
   - e. Tighten nuts securely

     (NOTE: Double wrench as in removal, hold terminals securely, and do not overtighten top nuts.)
   - f. Replace all brackets and shields
   - g. Tighten all bolts and nuts securely
   - h. Replace battery ground cable
   - i. Start engine several times to check starter

STARTING SYSTEMS
UNIT IV-C

JOB SHEET #2 — REPLACE STARTER REWIND SPRING

A. Tools and materials needed

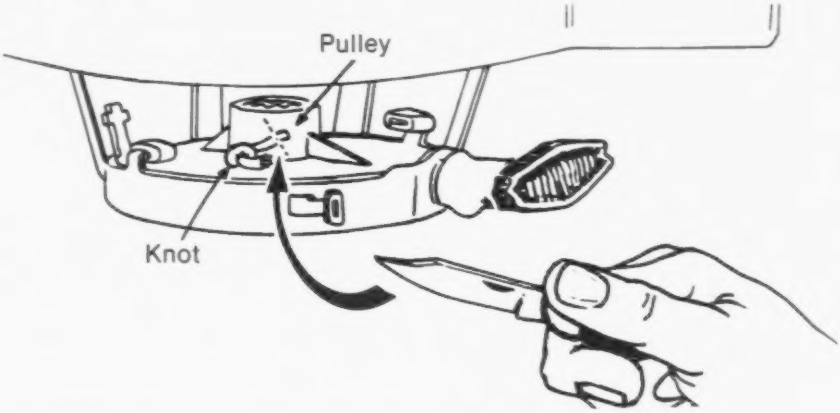
1. Hand tool assortment
2. Rope inserter
3. ¾" square piece of square stock
4. New recoil spring
5. New starter rope
6. Small amount of grease
7. Cleaning solvent
8. Safety glasses

B. Procedure

(NOTE: Wear proper safety equipment.)

1. Remove shroud or blower housing from engine
2. Turn blower housing upside down (Figure 1)

FIGURE 1



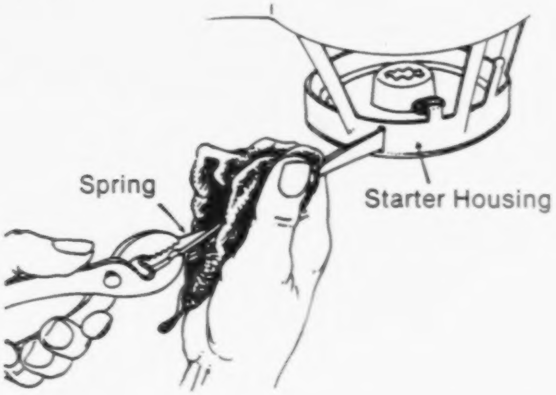
3. Cut knot at starter pulley and remove rope (Figure 1)

JOB SHEET #2

4. Grasp outer end of starter spring with pliers and pull spring out of housing as far as possible (Figure 2)

   (NOTE: Clean the spring with shop towel as you remove.)

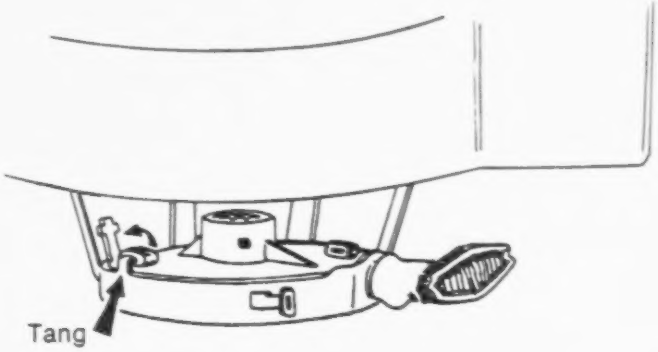
   FIGURE 2



5. Bend one of the tangs up and lift out starter pulley turning spring ¼ turn to disconnect (Figure 3)

   (CAUTION: Do not allow spring to fly out of housing as injury could result.)

   FIGURE 3



6. Clean starter housing pulley and spring in solvent and wipe dry

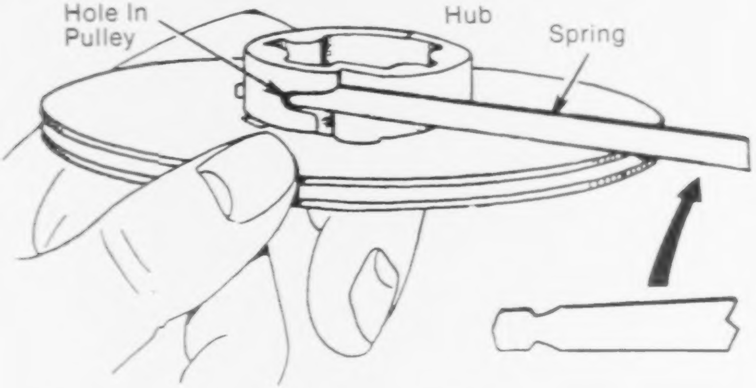
7. Straighten spring to allow easier installation and restore tension

   (NOTE: Replace spring if it is damaged; replace nylon bumpers if worn.)

JOB SHEET #2

8. Insert other end of spring through slot in blower housing, and hook the end of spring into pulley hub (Figure 4)

FIGURE 4

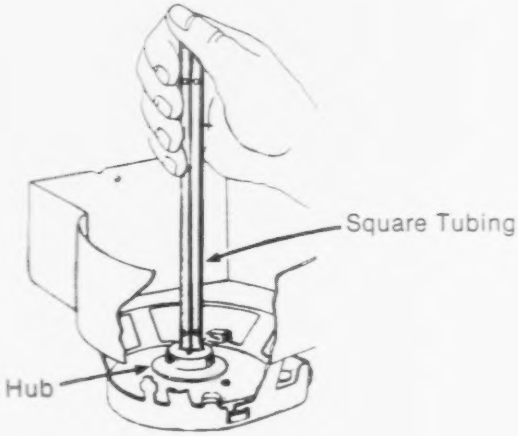


9. Place small amount of grease on pulley, set pulley into housing, and bend tang down

(NOTE: Make sure pulley is depressed fully into blower housing when measuring tang gap.)

10. Place 3/4" square tubing into center of pulley hub (Figure 5)

FIGURE 5

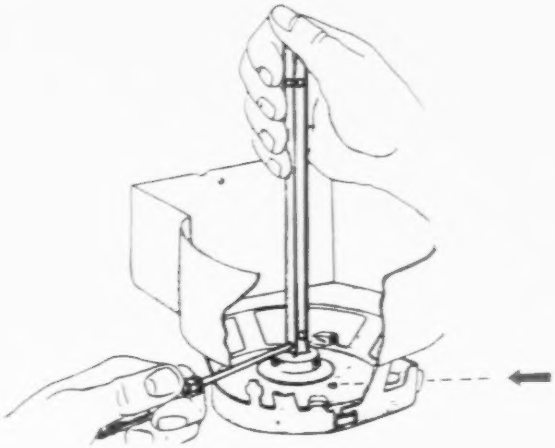


11. Wind pulley counterclockwise until spring is tight

JOB SHEET #2

12. Hold square tubing securely and back off the pulley one turn or until hole in pulley for rope and eyelet in blower housing are in alignment (Figure 6)

FIGURE 6

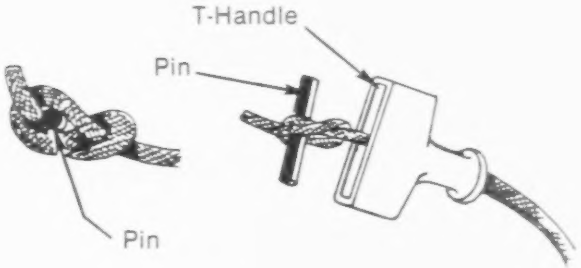


13. Replace starter rope with a new rope if it is frayed

(NOTE: Four feet of rope is needed for most starters and each end of new rope should be burnt with a match and wiped with a rag to prevent swelling and unraveling.)

14. Insert rope through T-handle and loosely tie a figure 8 knot; place the pin through the knot and pull it tightly into handle (Figure 7)

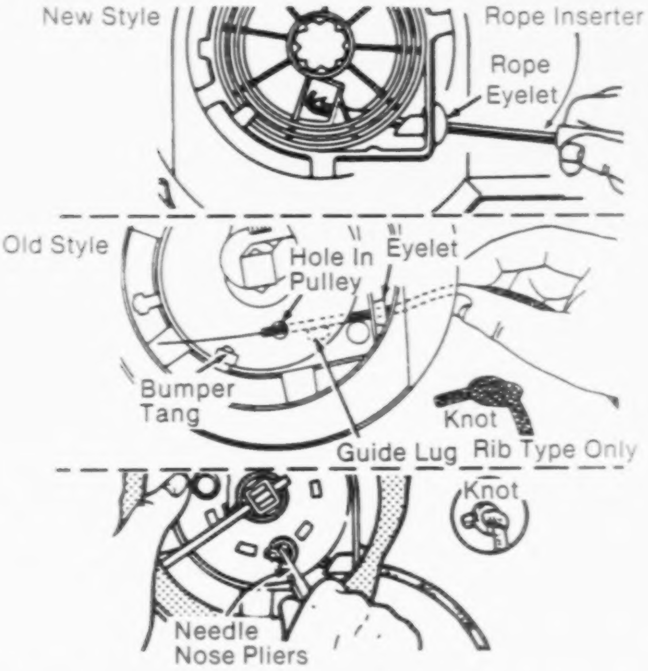
FIGURE 7



JOB SHEET #2

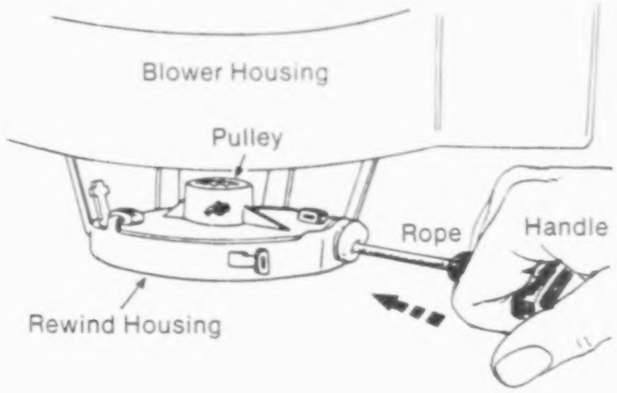
15. Use a rope inserter tool to thread rope through rope eyelet in housing and out pulley hole; tie a knot in rope and pull it tightly into knot cavity (Figure 8)

FIGURE 8


New Style
Rope Inserter
Rope Eyelet
Old Style
Hole In Pulley
Eyelet
Bumper Tang
Knot
Guide Lug
Rib Type Only
Knot
Needle Nose Pliers

16. Remove square tubing to release spring tension and allow rope to slowly rewind onto pulley (Figure 9)

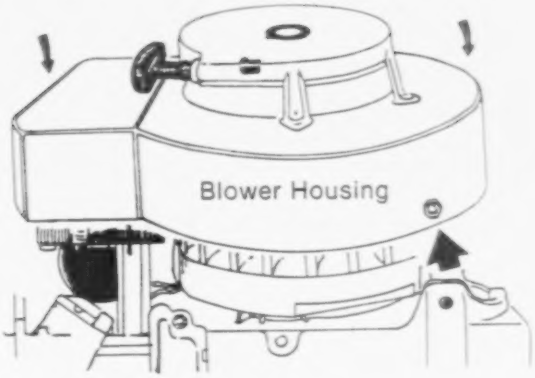
FIGURE 9


Blower Housing
Pulley
Rope
Handle
Rewind Housing

JOB SHEET #2

17. Install blower housing on engine (Figure 10)

FIGURE 10



18. Reconnect spark plug wire

19. Start engine several times to be sure starter is operating correctly

20. Clean work area and put tools away

STARTING SYSTEMS
UNIT IV-C

JOB SHEET #3 — SERVICE THE VERTICAL PULL STARTER

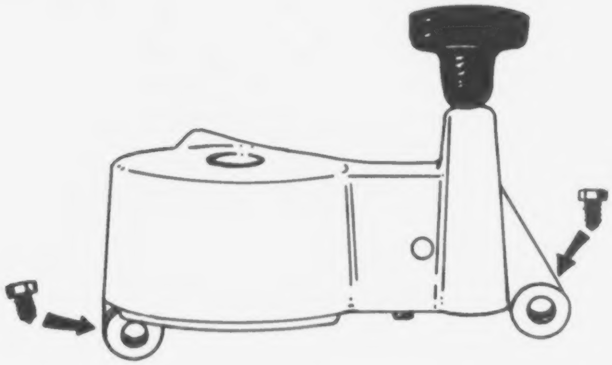
A. Tools and materials needed

1. New spring
2. New starter rope
3. Cleaning solvent
4. Safety glasses
5. Assortment of hand tools
6. Rope inserter tool
7. Safety gloves

B. Procedure

1. Read operator's manual
2. Wear proper safety equipment
3. Organize your work station
4. Disconnect spark plug wire
5. Remove starter from engine (Figure 1)

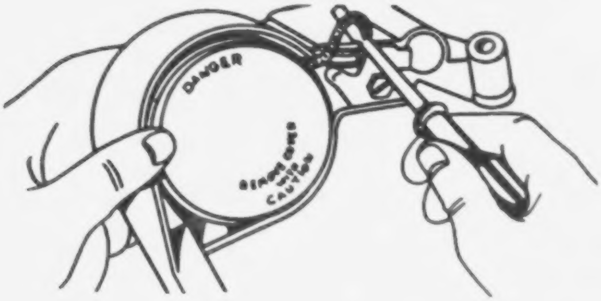
FIGURE 1



JOB SHEET #3

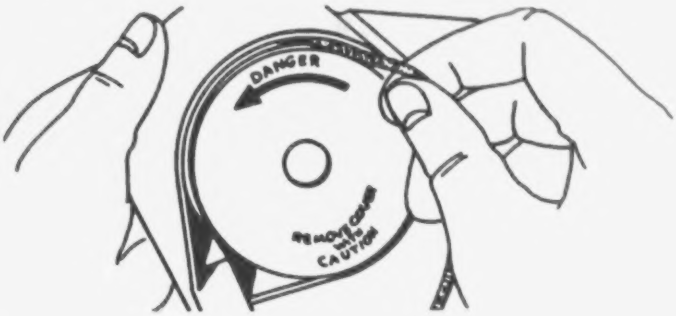
6. Remove tension from rope and use a screwdriver to lift the rope up 10 to 12 inches (Figure 2)

FIGURE 2


DANGER
REMOVE COVER WITH CAUTION

7. Wind the rope and pulley 2 to 3 turns counterclockwise to release spring tension (Figure 3)

FIGURE 3

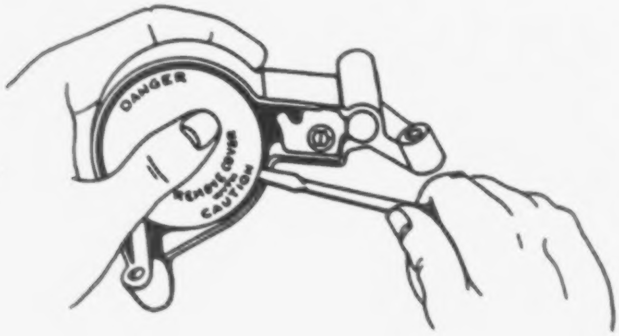

DANGER
REMOVE COVER WITH CAUTION

(CAUTION: Do not pull rope with pulley cover removed unless the spring is released.)

JOB SHEET #3

8. Remove cover with a screwdriver (Figure 4)

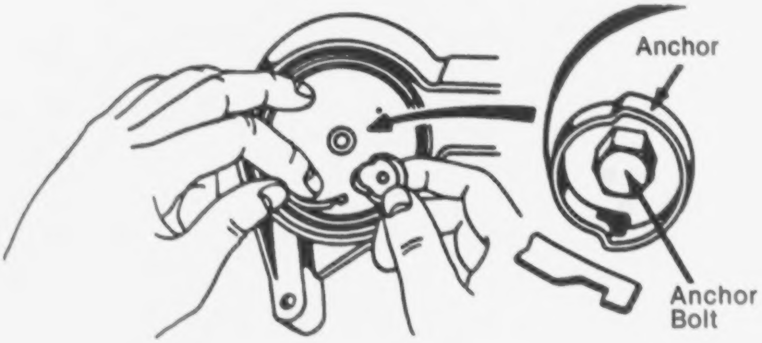
FIGURE 4


DANGER
REMOVE COVER
CAUTION

(CAUTION: Read warning on plastic cover and wear safety glasses.)

9. Remove anchor bolt and spring anchor to loosen pulley assembly from housing (Figure 5)

FIGURE 5

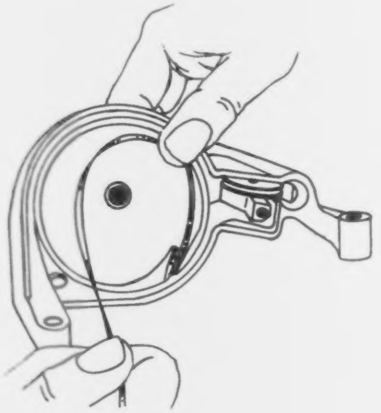

Anchor
Anchor Bolt

JOB SHEET #3

10. Carefully unwind spring, remove, and inspect for breakage (Figure 6)

(NOTE: If spring is not being removed, always replace pulley cover after removing the anchor bolt and spring anchor.)

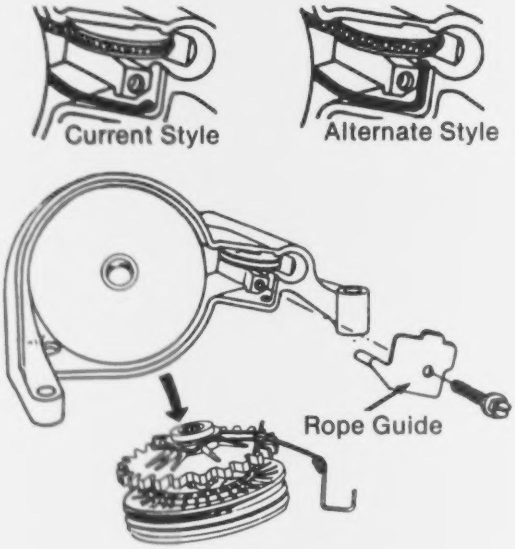
FIGURE 6



11. Remove rope guide (Figure 7)

(NOTE: Before removing pulley from housing, note position of the link for reassembly. Slowly remove pulley assembly from housing.)

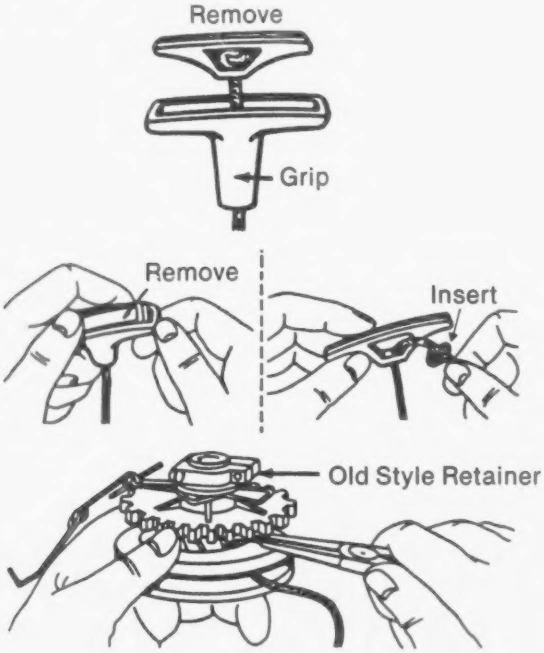
FIGURE 7


Current Style
Alternate Style
Rope Guide

JOB SHEET #3

12. Remove insert from handle and untie knot (Figure 8)

FIGURE 8


Remove
Grip
Remove
Insert
Old Style Retainer

13. Unwind rope from pulley, grasp knotted end with needle nose pliers, and remove rope (Figure 8)

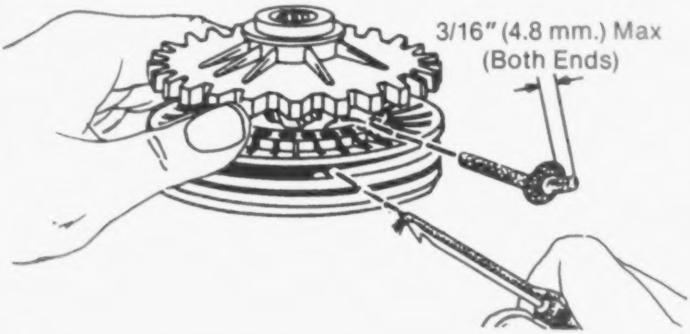
14. Clean all dirty or oily parts in solvent for reassembly

JOB SHEET #3

15. Insert new rope into the pulley, using the rope inserter tool and tie small knot, heat seal, and pull back into pulley (Figure 9)

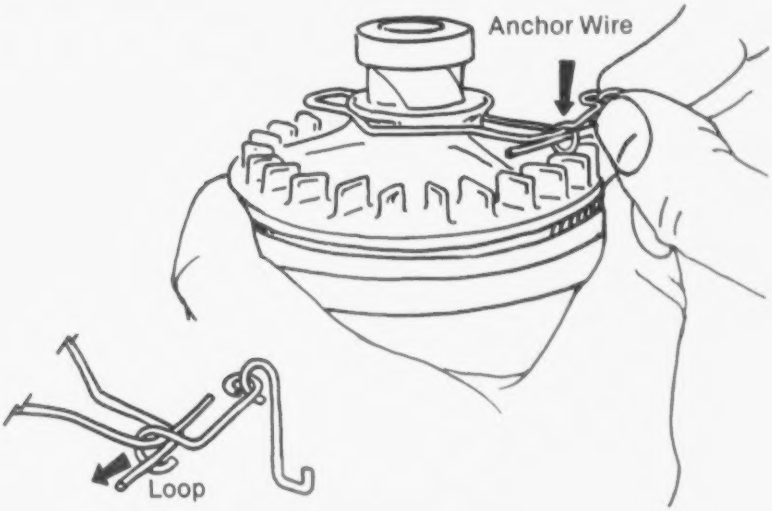
    (NOTE: Make sure rope does not interfere with gear assembly. Forty-eight inches of Number 4 rope will be needed.)

    FIGURE 9



16. When installing the break spring note the position of the loop on the anchor wire. The rounded portion should point toward the teeth of the gear (Figure 10)

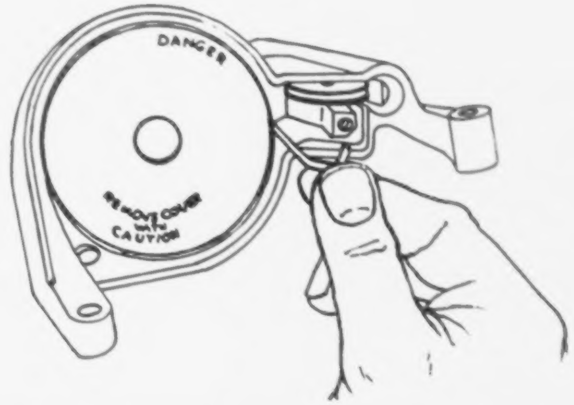
    FIGURE 10



JOB SHEET #3

17. Holding the link, install pulley assembly into housing (Figure 11)

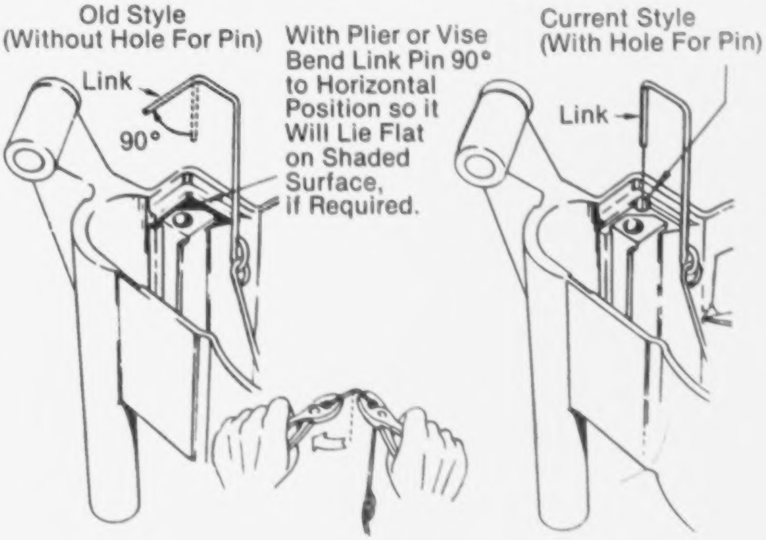
FIGURE 11


DANGER
REMOVE COVER WITH CAUTION

18. Using appropriate illustration, install link into housing (Figure 12)

(NOTE: Older link styles may be modified as illustrated.)

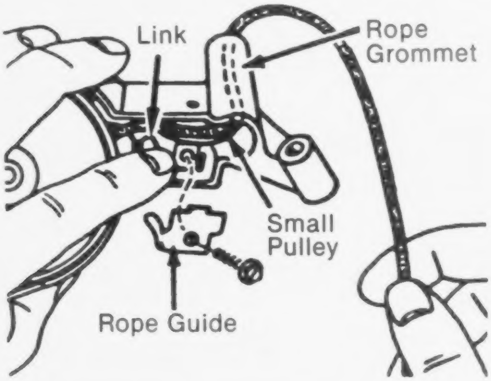
FIGURE 12


Old Style
(Without Hole For Pin)
Link
90°
With Plier or Vise Bend Link Pin 90° to Horizontal Position so it Will Lie Flat on Shaded Surface, if Required.
Current Style
(With Hole For Pin)
Link

JOB SHEET #3

19. Lead rope over small pulley, through rope grommet, and install rope guide (Figure 13)

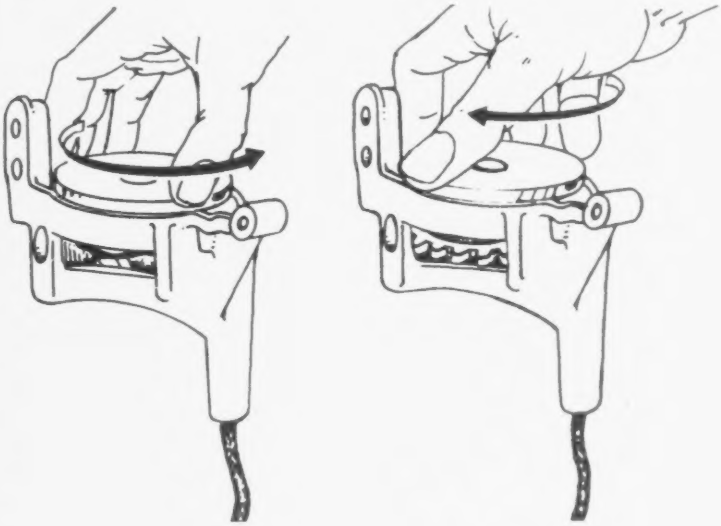
FIGURE 13


Link
Rope Grommet
Small Pulley
Rope Guide

20. Check the link for proper friction by manually rotating pulley assembly (Figure 14)

(NOTE: The gear should move to both extremes of its travel; if not, replace the link assembly.)

FIGURE 14



JOB SHEET #3

21. Thread rope through grip and into insert. Tie a small tight knot and heat seal to prevent loosening (Figure 15)

22. Pull knot into pocket and snap insert into grip (Figure 16)

FIGURE 15

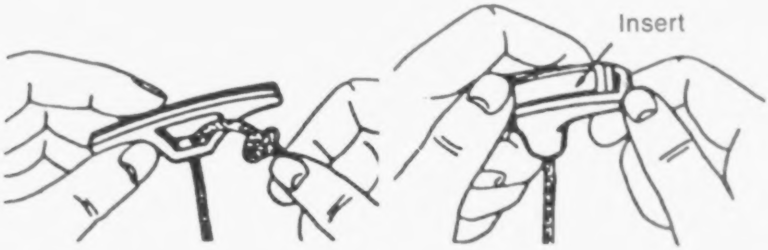
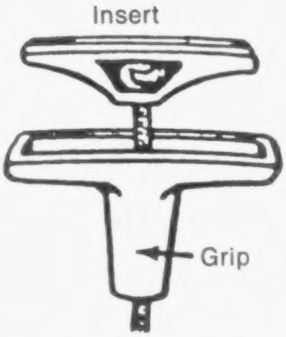
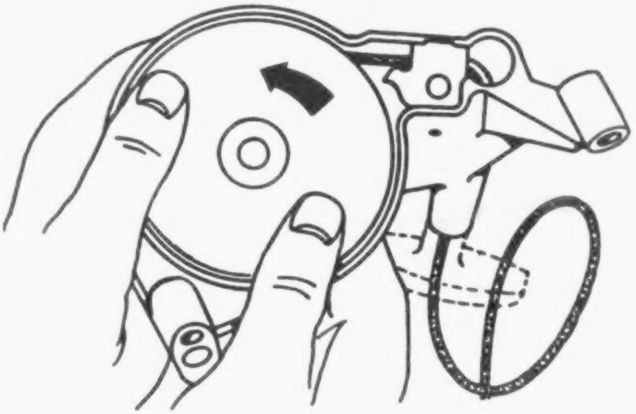


FIGURE 16



23. Wind pulley in a **counterclockwise** direction until rope is fully retrieved (Figure 17)

FIGURE 17

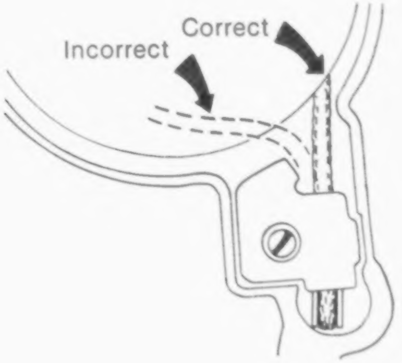


JOB SHEET #3

24. Check position of rope (Figure 18)

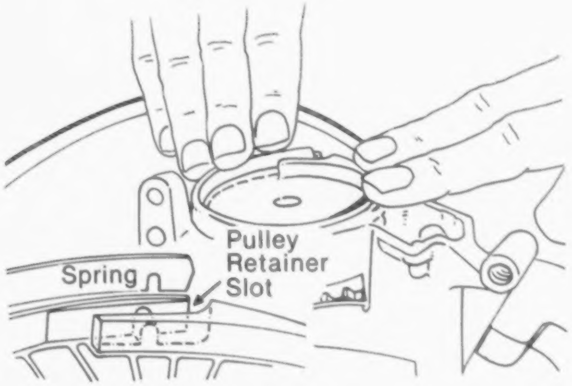
    (NOTE: It should not be touching the rope guide.)

    FIGURE 18


Correct
Incorrect

25. Secure starter in vice and oil the spring lightly (Figure 19)

    FIGURE 19

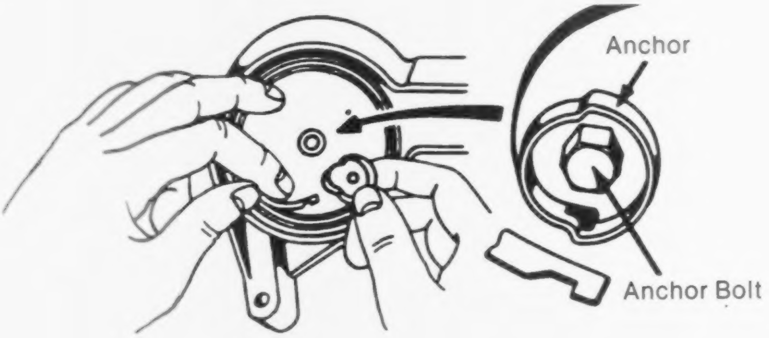

Pulley
Retainer
Slot
Spring

26. Install spring by hooking end in pulley retainer slot and wind spring into housing (Figure 19)

JOB SHEET #3

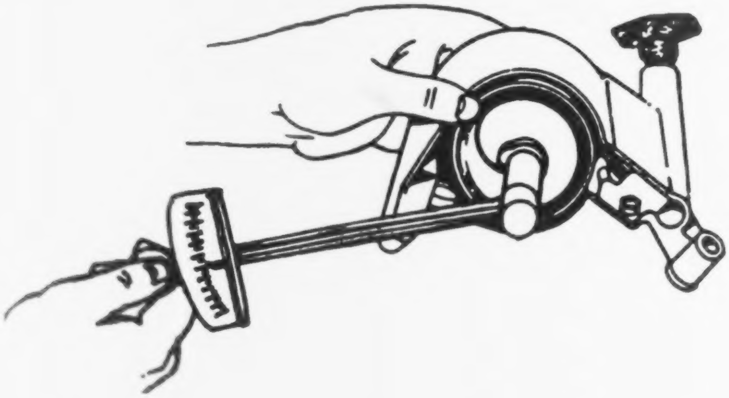
27. Hook end of spring to anchor and install bolt (Figure 20)

FIGURE 20


Anchor
Anchor Bolt

28. Torque to 75-90 inch-pounds and replace cover (Figure 21)

FIGURE 21

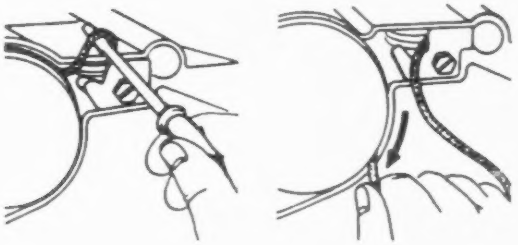


JOB SHEET #3

29. Wind rope in a **clockwise** direction two to three turns around pulley to secure proper spring tension (Figure 22)

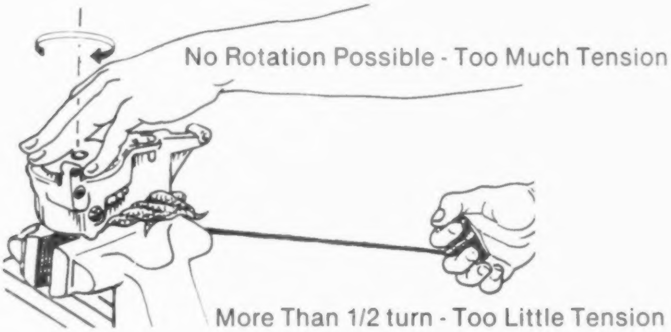
    (NOTE: To wind starter spring, pull approximately one foot of rope out of pulley.)

    FIGURE 22



30. Check spring tension (Figure 23)

    FIGURE 23


No Rotation Possible - Too Much Tension
More Than 1/2 turn - Too Little Tension

   a. When rope will not fully retract, wrap rope around pulley one more turn in a **clockwise** direction.

   b. If there is too much spring tension, pull the rope out so that it is fully extended and hold lightly; rotate the pulley clockwise

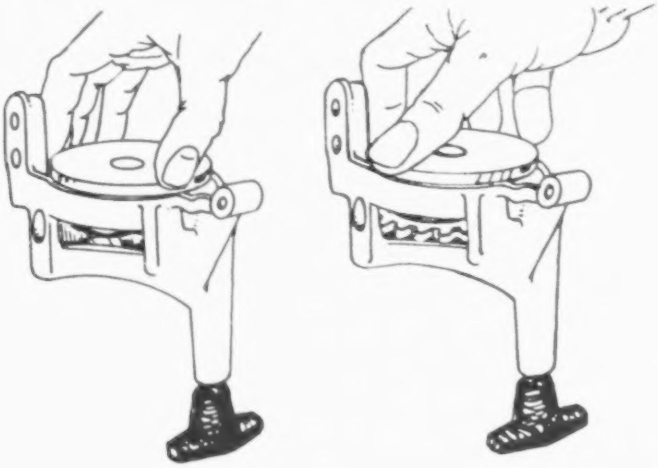
      (NOTE: The pulley should rotate no more than 1/2 turn. If pulley cannot be rotated, the spring is wound too tight. Unwind the rope one turn at a time until proper spring tension is obtained.)

JOB SHEET #3

31. Check starter for proper operation

(NOTE: The gear should move in and out.)

FIGURE 24



32. Install starter assembly on engine and check operation by pulling starter rope

(NOTE: Pulley gear should engage the flywheel.)

33. Reconnect the spark plug wire

34. Start engine several times to be sure starter is operating correctly

35. Clean your work area and put away tools

STARTING SYSTEMS
UNIT IV-C

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. Device which converts mechanical or electrical power into rotating motion for cranking engine

_____b. Housing which connects and contains starter component parts

_____c. Main shaft in starter, composed of commutator segments, windings, and bushing or bearing journal

_____d. Sliding contacts which transfer electrical energy to commutator

_____e. Gear that meshes with flywheel to crank engine

_____f. Ends of magnets in the field frame of a starting motor

_____g. Wire wrapped around pole pieces to increase the strength of the magnetic field when current is applied

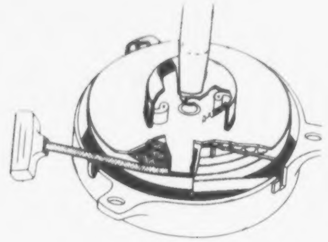
_____h. Safety device which allows engine to be started in neutral only

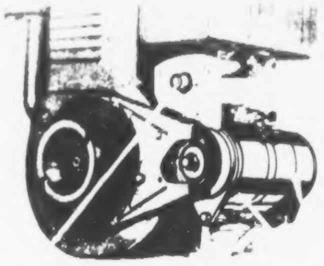
_____i. Electromagnetic device which provides a reciprocating motion for remote control of starting circuit

1. Solenoid
2. Brushes
3. Pole shoes
4. Starter frame
5. Safe interlock (neutral interlock)
6. Starter
7. Armature
8. Field coils
9. Starter drive pinion

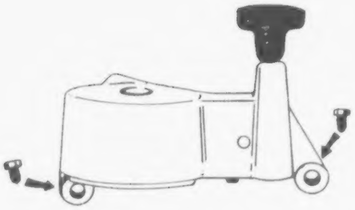
TEST

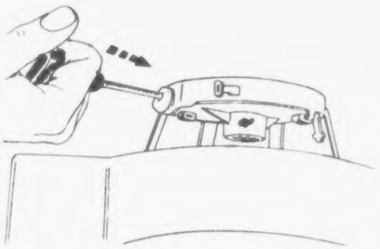
2. Identify the types of small gas engine starters.





a. ______________________ b. ______________________





c. ______________________ d. ______________________

TEST

3. Match the components of the mechanical starting system on the right with their correct functions.

_____a. Returns pawl to neutral position during rewind cycle

_____b. Locks pulley to crankshaft adapter on starting pull of rope

_____c. Housing for pawls that lock to crankshaft adapter

_____d. Used to automatically rewind the starter rope after each starting attempt

_____e. Cover for the starter mechanism

1. Starter housing
2. Recoil spring
3. Pawl spring
4. Engaging pawl
5. Pulley

4. Match the components of the DC starting system on the right with their correct functions.

_____a. Source of electrical power

_____b. Device which activates the starter motor switch

_____c. Switch which closes the high amperage circuit from battery to starter

_____d. Drives the flywheel to crank the engine

_____e. Conductor that carries a low amount of current to energize the starter motor switch

_____f. Conductors which carry large amounts of current to complete the starter circuit

1. Starter motor
2. Key switch
3. Battery cables
4. Battery
5. Switch wire
6. Starter motor switch

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

5. Demonstrate the ability to:

   a. Remove, disassemble, test, service, reassemble, and replace a starter (Job Sheet #1).

   b. Replace starter rewind spring (Job Sheet #2).

   c. Service the vertical pull starter (Job Sheet #3).

STARTING SYSTEMS
UNIT IV-C

ANSWERS TO TEST

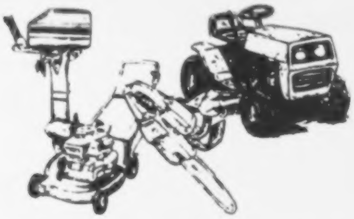
1. a. 6
   b. 4
   c. 7
   d. 2
   e. 9
   f. 3
   g. 8
   h. 5
   i. 1

2. a. Rope-rewind
   b. Electric (AC and DC)
   c. Vertical pull
   d. Rope-wind

3. a. 3
   b. 4
   c. 5
   d. 2
   e. 1

4. a. 4
   b. 2
   c. 6
   d. 1
   e. 5
   f. 3

5. Performance skills evaluated according to the standards identified by the instructor



Parts Management
Unit I-D

UNIT OBJECTIVE

After completion of this unit, the student should be able to price, stock, and inventory small engine parts. The student should also be able to use a parts catalog. Competencies will be demonstrated by correctly performing the procedures outlined in the assignment and job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to parts management with their correct definitions.
2. Select types of information found in the parts catalog.
3. List common parts by their abbreviations.
4. Complete a list of steps in using a parts catalog.
5. Select true statements concerning how to price parts correctly.
6. Complete a list of statements concerning the microfiche system and how to use it.
7. Select advantages of using computers in inventory control and stocking.
8. List advantages of good inventory control.
9. Select guidelines for taking a physical inventory.
10. Complete a service order (Assignment Sheet #1).
11. Demonstrate the ability to take a physical inventory of small engine parts (Job Sheet #1).

PARTS MANAGEMENT
UNIT I-D

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with assignment and job sheets.

H. Integrate the following activities throughout the teaching of this unit:

1. Invite a small engine repair shop owner to class to discuss parts storage and the inventory system.

2. Designate an area of shop as parts center and have students practice restocking procedures.

3. Furnish students with parts catalogs and have them practice looking up part numbers and prices. Have them make price comparisons between brands such as Champion vs. AC sparkplugs.

4. Discuss ways to order parts.

(NOTE: Stress the importance of phone orders when parts are needed quickly.)

5. Demonstrate proper use of the parts catalog.

6. Furnish students with an engine and/or appropriate information to complete Assignment Sheet #1. Repair information can be given to students, or instructor may prefer to have students check engine and determine parts to be replaced and work to be performed.

7. Demonstrate the proper procedure for taking a physical inventory.

SUGGESTED ACTIVITIES

8. Order training films from local NAPA dealer warehouse which deals with inventory control and show to students.
9. Take students to a parts warehouse which uses a computer for ordering parts and for inventory control. Or, invite a computer sales representative to class to discuss practical applications of a computer in a small engine shop.
10. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

    1. TM 1 — Master Parts Price List
    2. TM 2 — Abbreviations
    3. TM 3 — Standard Package
    4. TM 4 — Microfiche System
    5. TM 5 — Inventory Control Sheet

E. Assignment Sheet #1 — Complete a Service Order

F. Job Sheet #1 — Take a Physical Inventory

G. Test

H. Answers to test

REFERENCE USED IN DEVELOPING THIS UNIT

Fuqua, Lou and Debbie. *Parts Specialist.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1982.

PARTS MANAGEMENT
UNIT I-D

INFORMATION SHEET

I. **Terms and definitions**

A. Master parts catalog — Provides a means of determining the correct part number for pricing and ordering purposes

B. Footnote — A note of reference, explanation, or comment placed below the text on a given page; usually indicated by a small number or asterisk

C. Illustration lists — Exploded views of the parts with a reference number

D. Inventory — Parts and supplies on hand for sale to customers

E. Inventory control — Methods of keeping record of the quantity and type of merchandise on hand

F. Perpetual inventory — Record kept of each item showing the amount of merchandise put in stock, withdrawn, and on hand at any given time without the necessity of taking a physical count

II. **Types of information found in the parts catalog**

A. Model series illustrated parts and price list (Transparency 1)

B. Engines by type number and model

C. List of abbreviations (Transparency 2)

D. Standard package in ordering parts (Transparency 3)

III. **Common parts and their abbreviations (Transparency 2)**

Part	Abbreviation	Part	Abbreviation
Alternator	Alt	Magneto	Mag
Armature	Arma	Motor	Mtr
Bearing	Brg	Point	Pt
Carburetor	Carb	Regulator	Reg
Condenser	Cond	Retainer	Ret
Crankcase	Crkcse	Spring	Spg
Cylinder	Cyl	Starter	Str
Engine	Eng	Switch	Sw
Generator	Gen	Terminal	Term
Governor	Gov	Thermostat	Therm
Ignition	Ign	Valve	Vlv

INFORMATION SHEET

IV. Basic steps in using a parts catalog

A. Refer to engine model, type, and code number which may be found on the blower housing of the engine

(NOTE: Pertinent information may also be found in manufacturer's service manual.)

B. Refer to illustrated parts section; the number on the illustration is the reference number

C. After the reference number has been identified, refer to the numerical parts list where reference and master parts numbers are listed

(NOTE: The master part is used on all type numbers except those type numbers under "NOTE.")

D. If a "Note" appears below the master part number, this means this part differs from the master part for certain types; if the number is listed under "Note," order the part referred to

V. How to price parts correctly

A. Manufacturers' price sheets come in many forms

1. Some have list price, dealer price, and jobber price all together on one sheet

Example:

SUGGESTED PRICES			
PART NO.	LIST PRICE	DEALER PRICE	JOBBER PRICE
A-239	16.50	14.50	12.50
C-416	3.19	2.90	2.79
J-118	69.10	64.29	60.05

INFORMATION SHEET

2. Some have different colored pages for each type of price list

   Example:

Blue Sheet SUGGESTED JOBBER NET PRICES		Green Sheet SUGGESTED DEALER PRICES	
Catalog Number	Jobber Price	Catalog Number	Jobber Price
2002	11.50	2002	13.50
2003	12.50	2003	14.50
2004	13.50	2004	15.50
2005	14.50	2005	16.50
2006	15.50	2006	17.50
2007	16.50	2007	18.50
2008	17.50	2008	19.50
2009	18.50	2009	20.50

3. These lists quote different prices depending on the classification of the customer

4. It is very important to learn your company's discount procedures so you will charge customers from the appropriate price sheet

   (NOTE: Typical classifications are: consumers; fleet accounts; dealers; independent garages; industrial accounts; jobbers; government agencies.)

B. Use your price sheet every time you make a sale

(NOTE: Do not quote a price from memory.)

C. Remember, price sheets are CONFIDENTIAL, and some employers do not allow you to quote other than list prices over the phone

D. The "effective date" of a price sheet is important to notice because they must be kept current

VI. The microfiche system and how to use it (Transparency 4)

(NOTE: Many parts dealers record their catalog pages on microfilm and use microfiche readers; this eliminates much of the space needed for catalog racks.)

A. Catalog pages are reduced and put in rows of microimages on microfiche cards

B. Since these images are too small to read with the naked eye, microfiche readers are used to magnify the images and project them onto a viewing screen

INFORMATION SHEET

C. The microfiche cards then are labeled according to year, model, and types of parts shown on each card

D. When a customer gives you the necessary information to look up a part, you simply locate the corresponding card and place it in the reader

E. Find appropriate grouping and page for part needed

F. Choose correct part number

(NOTE: The same information is given in catalogs and on microfiche cards; the advantage of microfilm is the tremendous amount of material that can be condensed onto one card; for example, a catalog consisting of 1,000 pages or more could easily be contained on one 4" × 6" card.)

VII. Advantages of using computers in inventory control and stocking (Transparency 5)

A. Quickly produces an order printout for daily or weekly purchases from a supplier

B. Produces a clearly printed invoice for the customer

C. Automatically removes items sold from inventory

D. Saves time in the posting of items on inventory cards

E. Can be programmed to set minimums and maximums

F. Checks stock and identifies superseded items

G. An "on line" computer can order merchandise automatically

H. Can check suppliers stock automatically

I. Can check backorder items

(NOTE: The computer helps in many other areas of business operations, but is only as accurate as the person operating it.)

VIII. Advantages of good inventory control

A. Keeps supplies and parts up-to-date

B. Keeps track of damaged stock

C. Controls improperly binned stock

D. Keeps customer satisfaction up

E. Controls understocking or overstocking

F. Shows movement and turnover of stock

INFORMATION SHEET

IX. Guidelines for taking a physical inventory

A. Merchandise should be arranged by shelf or section, or the order in which the merchandise will be recorded on the inventory sheet

B. When filling out the description column use a wavy line to indicate the item is the same as the item on the previous line; do not use ditto (") marks on this column

C. Do not erase; cross out, using a pen or pencil for corrections

D. Write legibly because someone must read what you have written

(NOTE: Write dollars and cents accurately, making certain to keep the dollar amount in the dollar column and the cents in their column. Also write numbers such as 1, 4, 5, 7, 8, 9 as these numbers can be confused with one another.)

E. Do not leave spaces blank in any of the columns when recording stock items

F. Do not leave any lines blank

G. Count merchandise from the top shelf first moving from left to right then down

H. Quantities of an item should be listed per item with the price entered per item, and then extended and added to the total

Master Parts Price List

MASTER PARTS PRICE LIST

Part No.	List Price	Description	Dispo. Code	Stkg. Code	Std. Pkg.
22856	1.30	Lock-Rod Screw		5	
22859	.55	Retainer-Coil		4	
22880		Use 62899	C		
22890	7.55	Housing-Blower		5	
22906	.95	Lock-Nut		4	
22907	1.75	Support-Tank		3	
22918	3.55	Dipper-Conn Rod		5	
22927		Use 220805	A		
22928	2.00	Clip-Arm Spring		4	
22944	.65	Lock-Rod Screw		5	
22946	1.20	Lock-Rod Screw		4	
22947	1.10	Lock-Rod Screw		5	
22951	3.05	Shield-Cylinder		5	
22963	2@ .30	Washer-Cyl Head		3	20
23056	.85	Key-Dr Pulley		5	
23059	3.70	Lever-Shut Off		5	
23108	.80	Bushing-Shaft		3	10
23114	.55	Pin-Float Hinge		4	
23117	.80	Retainer-Valve		4	
23118	.75	Nut-Packing		4	
23123	.70	Screw-Choke Lev		3	10
23125		Use 93043	A		
23184	1.50	Retainer-Spring		2	10
23187	.65	Pin-Vlv Spg Ret		4	

Abbreviations

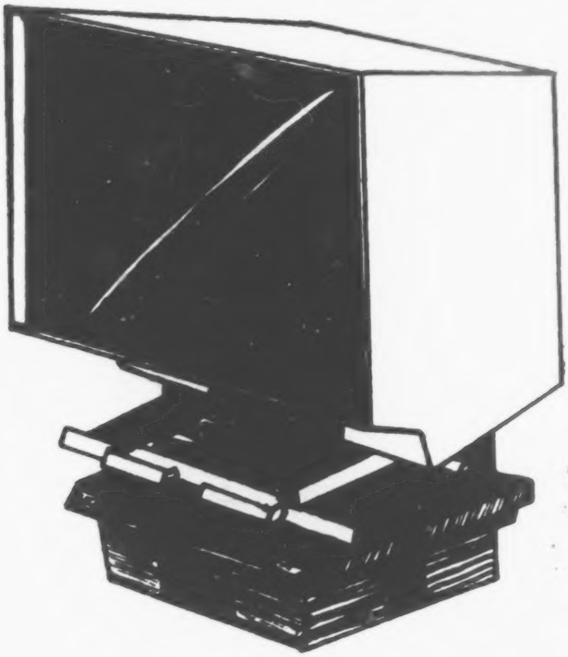
adj	adjusting
adv	advance
alt	alternator
arma	armature
assy	assembly
aux	auxiliary
brg	bearing
blo	blower
brkt	bracket
brkr	breaker
brea	breather
bshg	bushing
carb	carburetor
cl	cleaner
comb	combination
comp	compression
cond	condenser
conn	connecting
cntwgt	counterweight
cov	cover
crk	crank
crkcse	crankcase
crkstr	crankstarter
cyl	cylinder
defl	deflector
diaph	diaphragm
dr	drive
el	elbow
elec	electric
eng	engine
ex	exhaust
ext	extension
fill	fillister
flex	flexible
gen	generator
gov	governor
hd	head
hex	hexagon
hsg	housing
ign	ignition
inst	instrument
insul	insulator
int	intake
lev	lever
mag	magneto
man	manual
mani	manifold
mech	mechanical
mtr	motor
mtg	mounting
muff	muffler
pn	plain
pl	plate
pt	point
pull	pulley
rec	receptacle
rect	rectifier
reg	regulator
rep	repair
ret	retainer
rew	rewind
roto	rotocoil
rd	round
sp	spark
spg	spring
std	standard
str	starter
st	stop
sup	support
sw	switch
tap	tapping
term	terminal
therm	thermostat
thr	throttle
vlv	valve
volt	voltage

Standard Package

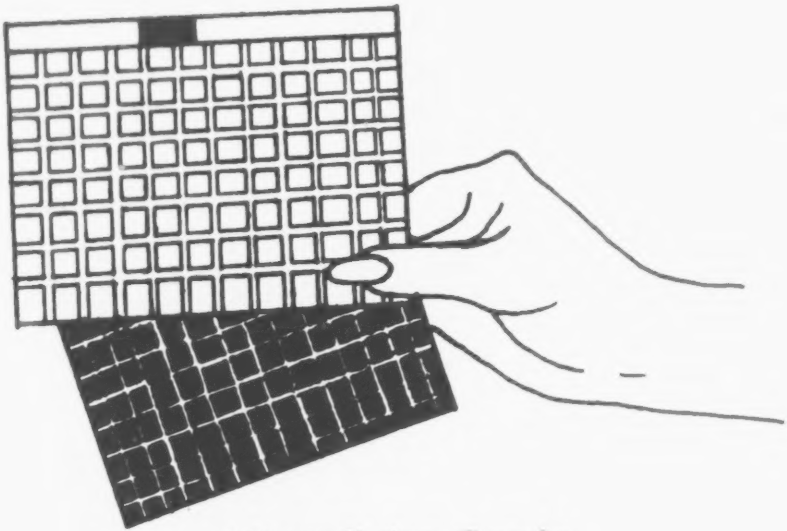
(NOTE: All parts are packaged singly, unless otherwise indicated in the "Price" column (example — 2 @ .30). Many parts are also offered in multiple package quantities, as shown in the "Standard Package" column.)

Part No.	List Price	Description	Dispo. Code	Stkg. Code	Pieces in Std. Pkg.
99176	3.15	Seal-Oil		4	
63770	2@ .30	Ball-Str Clutch		1	20
93911	.40	Spacer, Tank		2	10
290290	9.80	Ring Set-Std		2	10-100
270069	.40	Gasket, Crkcse		1	10-100-400

Microfiche System



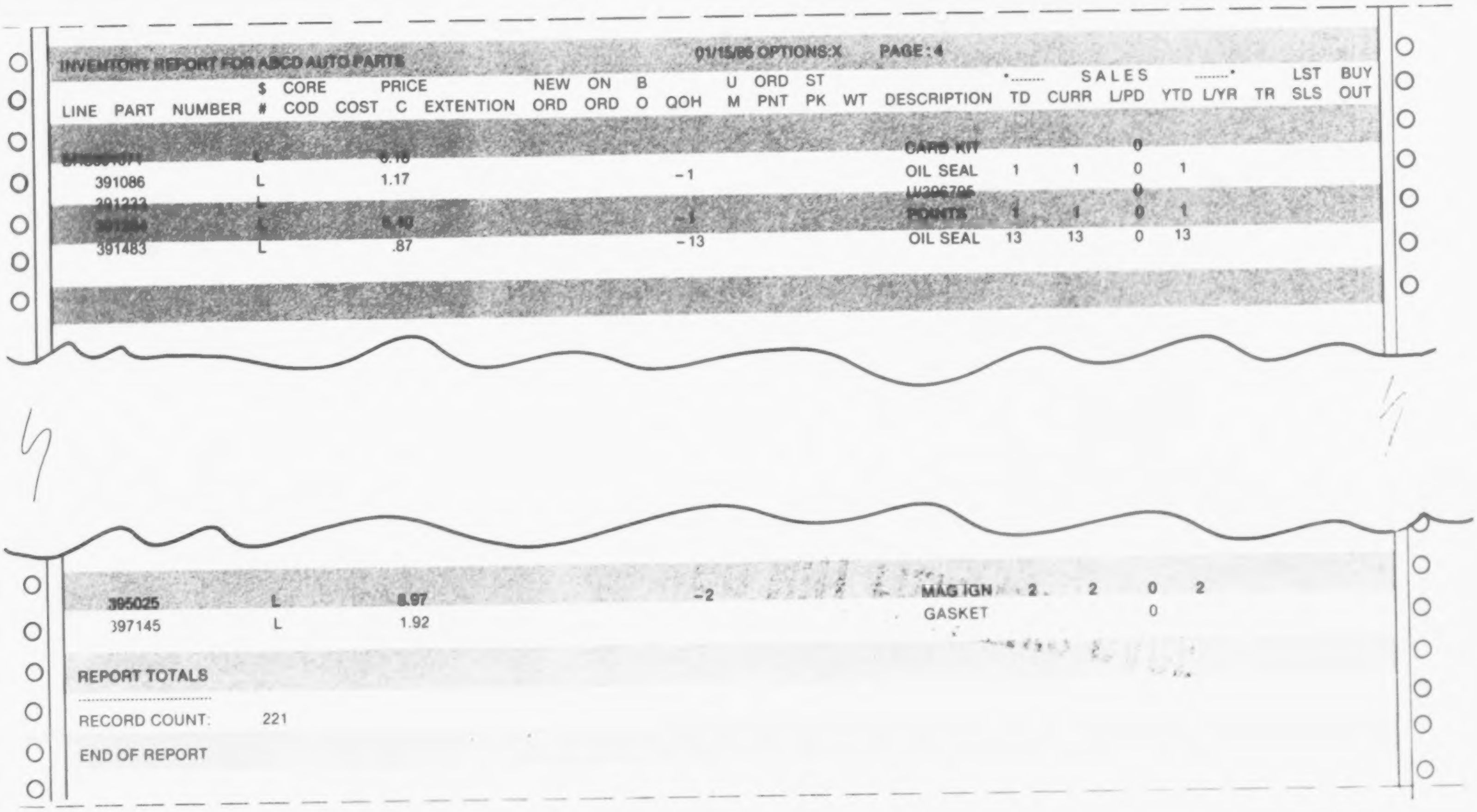
Microfiche Reader



Microfiche Cards

TM 4

Inventory Control Sheet



INVENTORY REPORT FOR ABCD AUTO PARTS 01/15/85 OPTIONS:X PAGE : 4

																SALES							
LINE	PART NUMBER	$ #	CORE COD	COST	PRICE C	EXTENTION	NEW ORD	ON ORD	B O	QOH	U M	ORD PNT	ST PK	WT	DESCRIPTION	TD	CURR	L/PD	YTD	L/YR	TR	LST SLS	BUY OUT
	[illegible]	L			[illegible]										CARB KIT			0					
	391086	L			1.17					-1					OIL SEAL	1	1	0	1				
	391233	L													W306705			0					
	391284	L			6.40					-1					POINTS	1	1	0	1				
	391483	L			.87					-13					OIL SEAL	13	13	0	13				
	395025	L			8.97					-2					MAG IGN	2	2	0	2				
	397145	L			1.92										GASKET			0					

REPORT TOTALS

RECORD COUNT: 221

END OF REPORT

PARTS MANAGEMENT
UNIT I-D

ASSIGNMENT SHEET #1 — COMPLETE A SERVICE ORDER

Directions: When preparing a service order, it is important to complete the form accurately. Using the information provided below, complete the service order on the following page.

Owner Information

Name: Joe Customer

Address: 1010 W. 15th St.
YourTown, YourState

Phone: 505-555-1111

Plan of Payment: Cash

Engine Information

(NOTE: Ask your instructor to provide either an engine or the appropriate information to complete this part of the assignment.)

Model No. __________

Serial No. __________

Type Equipment __________

Manufacturer __________

Date Purchased __________

Warranty Claim No. __________

Repair Information

Repair Person (Your Name)

Date Repaired (Today's Date)

Parts Replaced/Cost __________

Cost of Labor (NOTE: Figure the number of hours it took to complete work and multiply this by current hourly rate in your area.) __________

ORDER FOR NECESSARY PARTS

ALL PARTS INSTALLED ARE NEW UNLESS OTHERWISE SPECIFIED

COST	QTY	PARTS NO. or DESCRIPTION	PRICE

(MAY BE CONTINUED ON OTHER SIDE) **TOTAL PARTS** $

DATE

NUMBER

TANKS | Batteries | KEY NO. | ORDER TAKEN BY

ENGINE MAKE | MODEL

ENGINE SIZE | TYPE (IB, OB, I/O)

DAY RECEIVED | DAY PROMISED

SERIAL NO. ENGINE NO. 1 | SERIAL NO. DRIVE NO. 1

SERIAL NO. ENGINE NO. 2 | SERIAL NO. DRIVE NO. 2

NAME | HOME PH.

ADDRESS | BUS. PH.

CITY | STATE | ZIP

Make | Model | Year

STATE REGISTRATION NO. | Size | Hull No. | Hours

☐ CASH ☐ CHARGE ☐ INTERNAL

REPAIR ORDER INSTRUCTIONS: CHARGE TO: ( ) CUSTOMER ( ) WARRANTY

SERVICE ORDER AND INSTRUCTIONS	Labor Charge

☐ Launch ☐ Haulout ☐ Pickup ☐ Delivery

REPAIRMAN'S TRIPS TO AND FROM LOCATION **Hours** **Mileage**

ESTIMATE				ADDITIONS TO ESTIMATE			
PARTS	HOURS	LABOR	TOTAL	PARTS	HOURS	LABOR	TOTAL

Total Labor

Total Parts

Total Outside Repairs

ADDITIONS AUTHORIZED | TIME | DATE

BY

INTERNAL SUMMARY		
ACCT	CHARGE	COST

Sub Total

Tax

Gas

PAY THIS AMOUNT ➧ $

CUSTOMER'S CLEAR RECEIPT

I have examined the above described unit and find the work completed to my satisfaction. I hereby acknowledge receipt of the unit.

X

ALL WORK CASH ON DELIVERY

This Labor and Material is ordered by me, for which I have authority to order, to be listed at your regular prices. I agree to pay, cash when work is completed, or on satisfactory terms to you. If collection is made by suit or otherwise, I agree to pay interest until paid, also collection costs, including a reasonable Attorney fee, and hereby waive all rights to claim exemption under the State Laws, and an express mechanic's lien is acknowledged on above unit to secure the amount of repairs thereto.

It is understood and agreed that your company assumes no responsibility whatsoever for loss or damage by theft, fire, vandalism, water or any weather related damages, nor for any items of personal property left with the unit placed with you for repair storage or sale. I also authorize you and your employees to operate the above unit or rig for the purpose of transport, testing, inspection, pickup and/or delivery entirely at my risk.

THE RIGHT IS RESERVED TO SUBSTITUTE PARTS FOR THOSE CURRENTLY UNAVAILABLE.

STORAGE CHARGES WILL BE ADDED ON ALL ITEMS NOT PICKED UP WITHIN 10 DAYS AFTER NOTIFICATION OF COMPLETION OF SERVICE.

AUTHORIZED BY X

FORM 1950-3 JENKINS MARINE BUSINESS FORMS REV. 1-1-84
MASCOUTAH, IL 62258 Toll Free (800) 851-4424

469

BEST COPY AVAILABLE

PARTS MANAGEMENT
UNIT I-D

JOB SHEET #1 — TAKE A PHYSICAL INVENTORY

A. Materials needed

1. Inventory sheet
2. Pencil
3. Bins stocked with parts
4. Clipboard

B. Procedure

1. Prepare for inventory
    a. Pick a partner
    b. Clean bins
    c. Open boxes neatly and orderly for easy counting
    d. Identify and tag miscellaneous parts
2. Count and record inventory
    a. Fill out heading on inventory sheet
    b. Have caller start at top, far left, corner of bin
    c. Move to the right and down recording every item on the shelves
    d. Price and extend costs as you go
    e. Total inventory sheets
    f. After completing these steps, hand your inventory to your instructor for evaluation

JOB SHEET #1

Inventory______________________________ PAGE__________

SHEET NO.___________________________________ PRICED BY____________

CALLED BY____________ DEPARTMENT____________ EXTENDED BY____________

ENTERED BY____________ LOCATION____________ EXAMINED BY____________

QUANTITY	UNIT	DESCRIPTION	PRICE	UNIT	EXTENSION	TOTAL

PARTS MANAGEMENT
UNIT I-D

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

______a. Provides a means of determining the correct part number for pricing and ordering purposes

______b. A note of reference, explanation, or comment placed below the text on a given page; usually indicated by a small number or asterisk

______c. Exploded views of the parts with a reference number

______d. Parts and supplies on hand for sale to customers

______e. Methods of keeping record of the quantity and type of merchandise on hand

______f. Record kept of each item showing the amount of merchandise put in stock, withdrawn, and on hand at any given time without the necessity of taking a physical count

1. Inventory
2. Footnote
3. Perpetual inventory
4. Master parts catalog
5. Illustration lists
6. Inventory control

2. Select types of information found in the parts catalog by placing an "X" in the appropriate blanks.

______a. Model series illustrated parts and price list

______b. Methods of keeping parts inventory

______c. Engines by type number and model

______d. List of abbreviations

______e. Standard package in ordering parts

______f. Competitor's price lists

TEST

3. List common parts by their abbreviations in the spaces provided.

   a. Alternator ____________________
   b. Bearing ____________________
   c. Crankcase ____________________
   d. Cylinder ____________________
   e. Governor ____________________
   f. Ignition ____________________
   g. Motor ____________________
   h. Point ____________________
   i. Retainer ____________________
   j. Starter ____________________
   k. Terminal ____________________
   l. Valve ____________________

4. Complete the following list of steps in using a parts catalog by correctly filling in the blanks.

   a. Refer to engine model, type, and code number which may be found on the ________________ of the engine

   b. Refer to illustrated parts section; the number on the illustration is the ________________ number

   c. After the reference number has been identified, refer to the ________________ parts list where reference and master parts numbers are listed

   d. If a "Note" appears below the master part number, this means this part ________________ from the master part for certain types; if the number is listed under "Note," order the part referred to

5. Select true statements concerning how to price parts correctly by placing an "X" in the appropriate blanks.

   ______a. Some manufacturers' price sheets have list price, dealer price, and jobber price all together on one sheet

   ______b. Each type of price list is a different color

   ______c. Price lists quote different prices depending on the classification of the customer

   ______d. It is very important to learn your company's discount procedures so you will charge customers from the appropriate price sheet

   ______e. It is OK to quote a price once you have the price list memorized

   ______f. Price sheets are CONFIDENTIAL and some employers do not allow you to quote other than list prices over the telephone

   ______g. The "effective date" of a price sheet is important to notice because they must be kept current

TEST

6. Complete the following list of statements concerning the microfiche system and how to use it by correctly filling in the blanks.

   a. Catalog pages are reduced and put in rows of ________________ on microfiche cards

   b. Since these images are too small to read with the naked eye, ________________ are used to magnify the images and project them onto a viewing screen

   c. The microfiche cards then are labeled according to ________________, model, and types of parts shown on each card

   d. When a ________________ gives you the necessary information to look up a part, you simply locate the corresponding card and place it in the reader

   e. Find appropriate ________________ and page for part needed

   f. Choose correct ________________ number

7. Select advantages of using computers in inventory control and stocking by placing an "X" in the appropriate blanks.

   _____a. Quickly produces an order printout for daily or weekly purchases from a supplier

   _____b. Produces a clearly printed invoice for the customer

   _____c. Automatically removes items sold from inventory

   _____d. Saves time in the posting of items on inventory cards

   _____e. Can be programmed to run the parts department

   _____f. Checks stock and identifies superseded items

   _____g. An "on line" computer can order merchandise automatically

   _____h. Can check suppliers stock automatically

   _____i. Can check backorder items

8. List four advantages of good inventory control.

   a. ____

   b. ____

   c. ____

   d. ____

TEST

9. Select guidelines for taking a physical inventory by placing an "X" in the appropriate blanks.

_____a. Merchandise should be arranged by shelf or section, or the order in which the merchandise will be recorded on the inventory sheet

_____b. When filling out the description column use a dotted line to indicate the item is the same as the item on the previous line; do not use ditto (") marks on this column

_____c. Erase for corrections

_____d. Write legibly because someone must read what you have written

_____e. Do not leave spaces blank in any of the columns when recording stock items

_____f. Do not leave any lines blank

_____g. Count merchandise from the bottom shelf first moving from left to right then up

_____h. Quantities of an item should be listed per item with the price entered per item, and then extended and added to the total

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

10. Complete a service order (Assignment Sheet #1).

11. Demonstrate the ability to take a physical inventory of small engine parts (Job Sheet #1).

PARTS MANAGEMENT
UNIT I-D

ANSWERS TO TEST

1. a. 4
   b. 2
   c. 5
   d. 1
   e. 6
   f. 3

2. a,c,d,e

3. a. Alt
   b. Brg
   c. Crkcse
   d. Cyl
   e. Gov
   f. Ign
   g. Mtr
   h. Pt
   i. Ret
   j. Str
   k. Term
   l. Vlv

4. a. Blower housing
   b. Reference
   c. Numerical
   d. Differs

5. a,c,d,f,g

6. a. Microimages
   b. Microfiche readers
   c. Year
   d. Customer
   e. Grouping
   f. Part

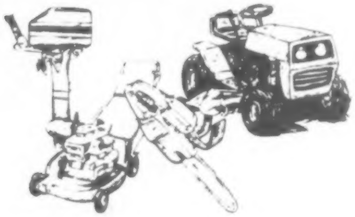
7. a,b,c,d,f,g,h,i

8. Any four of the following:
   a. Keeps supplies and parts up-to-date
   b. Keeps track of damaged stock
   c. Controls improperly binned stock
   d. Keeps customer satisfaction up
   e. Controls understocking or overstocking
   f. Shows movement and turnover of stock

9. a,d,e,f,h

10. Evaluated according to standards identified by the instructor

11. Performance skills evaluated according to standards identified by the instructor



Lubrication Systems
Unit II-D

UNIT OBJECTIVE

After completion of this unit, the student should be able to change the engine oil and filter and service the crankcase breather. Competencies will be demonstrated by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to lubrication systems with their correct definitions.
2. Distinguish between the two types of lubrication systems.
3. Select purposes of the crankcase breather.
4. Match components of the crankcase breather with their correct purposes.
5. Complete a list of functions of engine oil.
6. Select characteristics of a good engine oil.
7. Complete a list of statements concerning the SAE viscosity number.
8. Complete a list of statements concerning the API classification system.
9. List oil contaminants.
10. Match oil additives with their correct functions.
11. Select factual statements about oil.

OBJECTIVE SHEET

12. Complete a list of statements concerning the selection and use of oils for best engine performance.

13. Select true statements concerning two cycle oil selection and use.

14. Demonstrate the ability to:

    a. Change engine oil and filter (Job Sheet #1).

    b. Service crankcase breather (Job Sheet #2).

LUBRICATION SYSTEMS
UNIT II-D

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets prior to the demonstration of the procedures.

H. Integrate the following activities throughout the teaching of this unit:

  1. Invite an industry representative to talk on lubricants.
  2. Identify problems by inspecting damaged engine blocks.
  3. Run an old engine without oil and have students check engine for damage.
  4. Demonstrate and discuss the procedures outlined in the job sheets.
  5. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

SUGGESTED ACTIVITIES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

  1. TM 1 — Dipper Lubrication System
  2. TM 2 — Slinger Lubrication System
  3. TM 3 — Dipper, Pump, and Constant-Level Sump
  4. TM 4 — Crankcase Breather
  5. TM 5 — Crankcase Breather Vented to Carburetor
  6. TM 6 — Crankcase Breather Principles (4-Cycle Engine)
  7. TM 7 — A Typical Crankcase Breather
  8. TM 8 — Comparison of Crankcase Oils (Viscosity-Grades)
  9. TM 9 — API Classification System

E. Job sheets

  1. Job Sheet #1 — Change Engine Oil and Filter
  2. Job Sheet #2 — Service Crankcase Breather

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Fundamentals of Service: Fuels, Lubricants, and Coolants.* Moline, Illinois: Deere and Company, 1979.

B. *Fuels and Lubricants.* Fifth Edition. Athens, Georgia: American Association for Vocational Instructional Materials, 1983.

C. Herd, Amon. *Lubricating Small Engines.* Columbia, Missouri: Instructional Materials Laboratory, University of Columbia.

D. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

LUBRICATION SYSTEMS
UNIT II-D

INFORMATION SHEET

I. **Terms and definitions**

A. Additives — Certain chemicals added to oil to provide extra performance

B. Multi-grade oils — Oils compounded to behave as light oils at cold temperatures and heavy oils at warm temperatures

C. SAE — Society of Automotive Engineers

D. API — American Petroleum Institute

E. Friction — Resistance to movement between two objects placed in contact with one another

F. "W" oils — Types of oils that are suitable for winter service

(NOTE: Type "W" viscosities are determined at 0°F or -18°C.)

G. Sludge — Heavy, thick residue found in the bottom of an oil pan caused by oil deterioration or oil contamination

H. Blow-by — Gases under pressure leaking by the piston rings during combustion and the power stroke

I. Dipper — Device fastened to connecting rod as a means of splashing oil

J. Slinger — Device rotated by the camshafts for splashing oil

K. Oil gally (passage) — Passageways in the engine used to carry oil from one area to another

L. Pressure relief valve — Valve in the lubrication system designed to limit maximum oil pressure

M. Oil pickup — Device allowing the oil pump to pick up oil which is free from sediment in the oil pan

N. Oil pan (sump) — Cover on the bottom of the engine block providing a reservoir for the engine oil

O. Oil filter — Device used to remove abrasive particles from the oil

P. Viscosity — A measure of the fluidity of an oil at a given temperature

INFORMATION SHEET

II. **Types of lubrication systems (Transparencies 1, 2 and 3)**

(NOTE: Some engines use both systems.)

A. Splash system

1. Dipper type

2. Slinger types

B. Pump system

1. Barrel and plunger type

2. Gear and rotor type

III. **Purposes of crankcase breather (Transparencies 4, 5, and 6)**

A. Allows blow-by to escape

B. Limits corrosion of engine parts

C. Prevents oil leaks at seals and gaskets by relieving crankcase pressure

D. Allows entrance of fresh air

IV. **Components of the crankcase breather and their purposes (Transparency 7)**

A. Cover (valve) — Prevents entrance of excessive amounts of dirt

B. Filter — Prevents dirt and abrasives from entering air

C. Baffle — Keeps excessive oil from splashing onto filter

D. Reed — Limits amount of fresh air entering crankcase and allows blow-by to leave engine

V. **Functions of engine oil**

A. Reduces friction and wear

B. Cools moving parts

C. Helps seal cylinders

D. Keeps parts clean

E. Cushions moving parts

INFORMATION SHEET

VI. **Characteristics of good engine oil**

- A. Keeps a protective film on moving parts
- B. Resists breakdown at high temperatures
- C. Resists corrosion and rusting
- D. Prevents carbon build-up
- E. Prevents sludge formation
- F. Flows easily at low temperatures
- G. Resists foaming
- H. Resists breakdown after long use

VII. **SAE viscosity number (Transparencies 8 and 9)**

(NOTE: SAE is the viscosity established by Society of Automotive Engineers.)

- A. Oils vary in viscosity as temperatures change

  (NOTE: Oil becomes more fluid as temperatures increase and less fluid as temperatures decrease.)

- B. Lighter oils for winter use are specified at 0°F and carry a 5w, 10w or 20w symbol

  (NOTE: Specifications are determined by time of flow through an instrument, such as a Saybolt viscometer, in seconds.)

- C. Heavier oils are specified at 210°F and carry a 20, 30, 40, or 50 viscosity number

  (NOTE: Compounded oils called multi-grade behave as light oils in cold temperatures and heavier oils at high temperatures, for example 10w-40 can replace four single grade oils.)

VIII. **API oil classification system (Transparency 9)**

- A. Standardized specifications for oil qualities between the engine manufacturer, the petroleum industry, and the customer
- B. Four service classifications found on oil cans include
  1. SC — Oil meeting the 1964-1967 warranty requirements of automobile manufacturers

INFORMATION SHEET

2. SD — Oil meeting the 1968-1971 warranty requirements
3. SE — Oil meeting the 1972-1979 warranty requirements
4. SF — Oil meeting the 1980 warranty requirements

IX. **Oil contaminants**

A. Foreign particles

B. Water

C. Antifreeze

D. Fuel

E. Oxidation

F. Acids

X. **Oil additives and their functions**

(NOTE: Most oils already have these additives.)

A. Anti-corrosion — Helps prevent failure of alloy bearings from corrosive acids caused by combustion

B. Oxidation inhibitor — Prevents acid, varnish, and sludge formations

(NOTE: Oxidation causes oil to thicken.)

C. Anti-rust — Prevents rusting of metal parts during storage or downtime

D. Viscosity index improver — Helps oil give top lubricating protection at both high and low temperatures

E. Pour point depressant — Prevents wax crystals from congealing in cold weather and forming clumps

F. Extreme pressure — Assures lubrication where extreme pressures between close tolerances are encountered

G. Detergent-dispersant — Helps keep metal surfaces clean and prevents deposit formation

H. Foam inhibitor — Helps prevent air bubbles which would restrict lubrication

(NOTE: Fast circulation causes oil to foam.)

INFORMATION SHEET

XI. **Factual statements about oil**

A. Oil becomes unfit for further use as it absorbs contaminants and as additives are depleted

B. Multi-viscosity oils are not always preferred

C. Black oil does not mean time for an oil change

D. Buy quality oil filters as recommended by machine operator's manual

E. Oil oxidation results in thicker oil

F. Using a light oil until consumption increases, and then switching to a heavier oil, is not a good practice

G. Following operator's manual recommendations is critical to insure good performance

XII. **Selection and use of oils for best engine performance**

A. Use brands which meet engine manufacturer's specifications

B. Drain and change at recommended intervals

C. Select oils which have been performance tested

D. Never mix oils of various specifications

E. Bring engine up to normal operating temperature each time it is used

F. Use clean oil containers and keep covered, sealed, and protected to prevent contamination

G. Replace or clean filters before they become plugged

XIII. **Two cycle oil selection and use**

A. Selection

1. Select only manufacturer's recommended rating

(NOTE: Pumps on oil injection systems are designed for the weight oil recommended by the manufacturer. Using wrong rating can affect lubrication.)

INFORMATION SHEET

2. Select only oil recommended for use in either air cooled or water cooled two cycle engines

   (NOTE: The use of standard detergent oils can cause carbon build up in cylinder head and around moving parts.)

B. Use

(NOTE: There are no SAE standards for two cycle oils. Currently four cycle standards are being used.)

1. Use oil-fuel mixture recommended by manufacturer

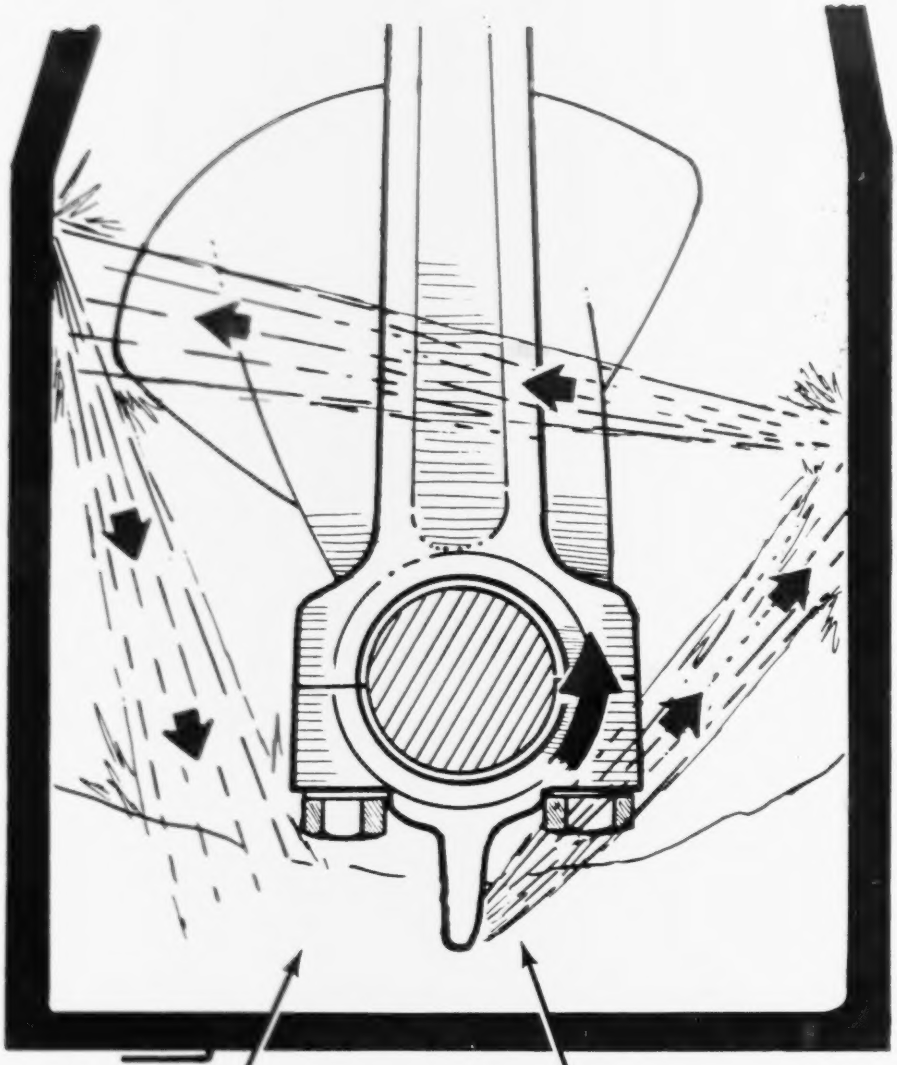
   (NOTE: Just because an oil is rated for a 50-1 mixture doesn't mean your engine is.)

2. Use oils that meet or exceed manufacturer's recommendations

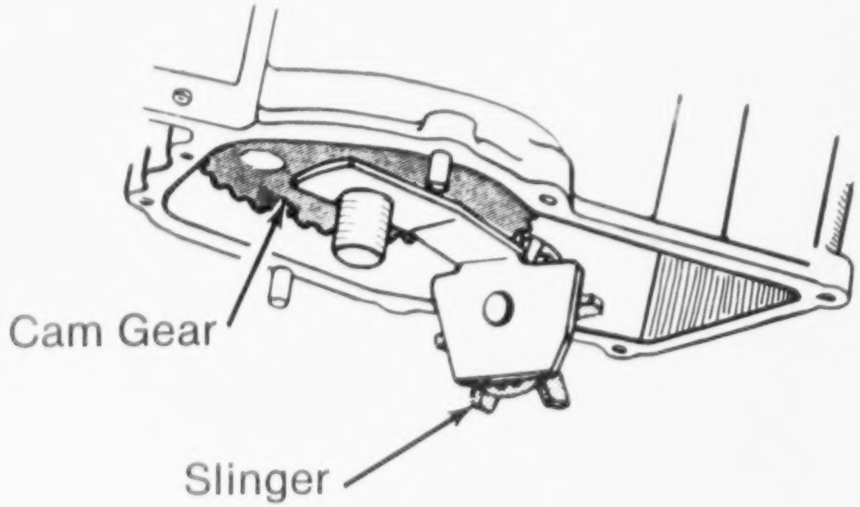
   (NOTE: A good quality oil may seem expensive when compared to a more economical brand, but it is inexpensive when compared to an overhaul.)

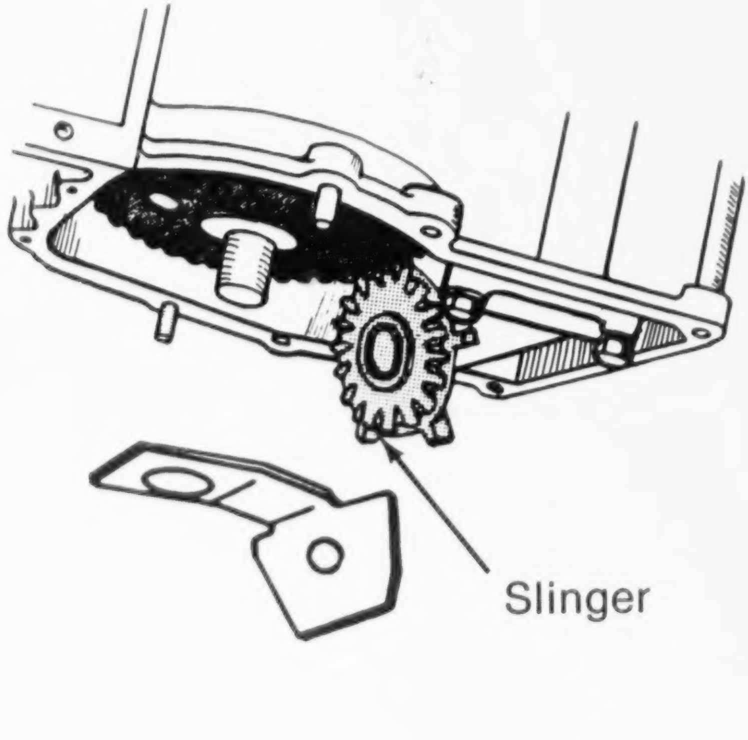
3. Never mix synthetic oils with mineral oils

Dipper Lubrication System

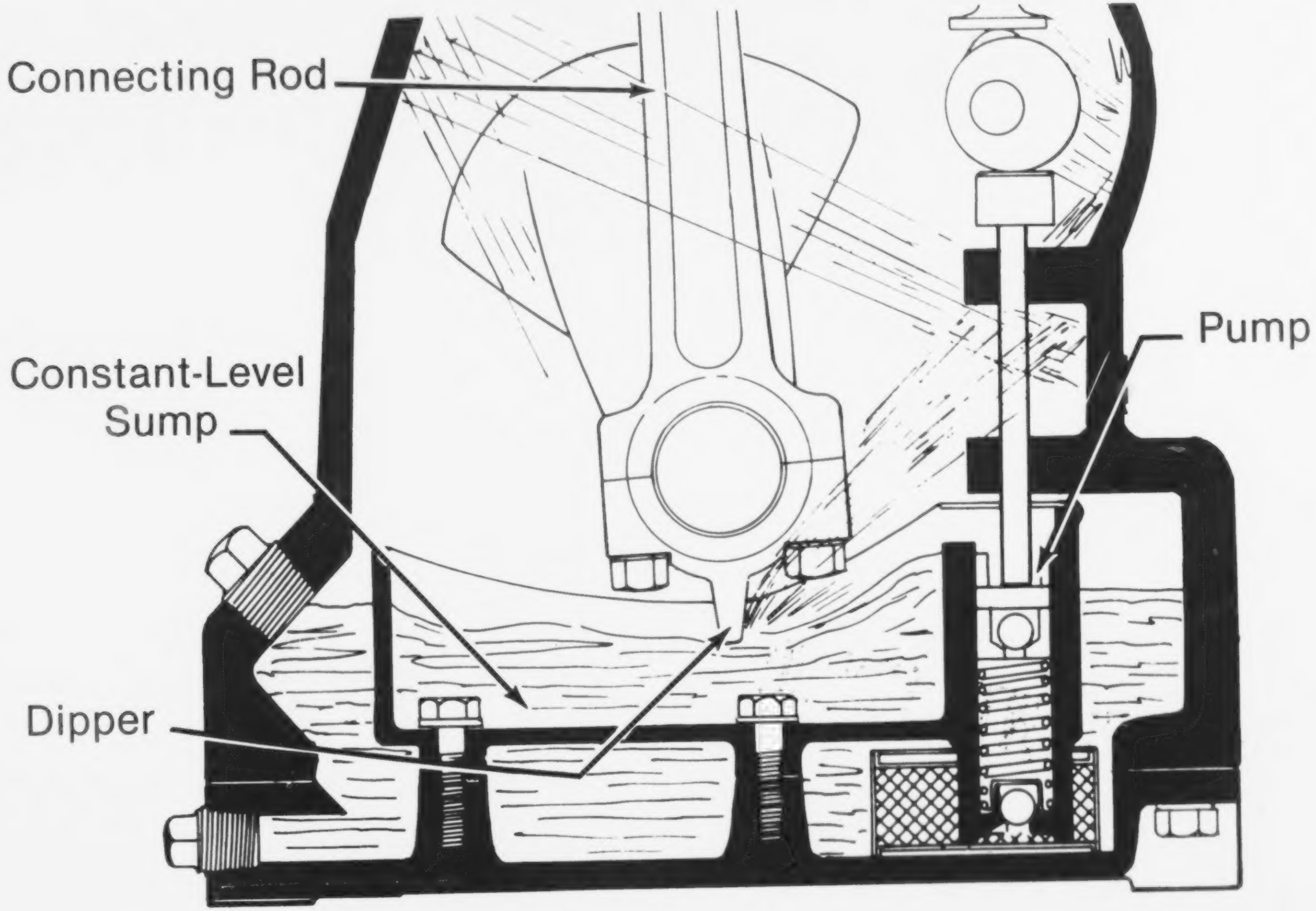


Slinger Lubrication System

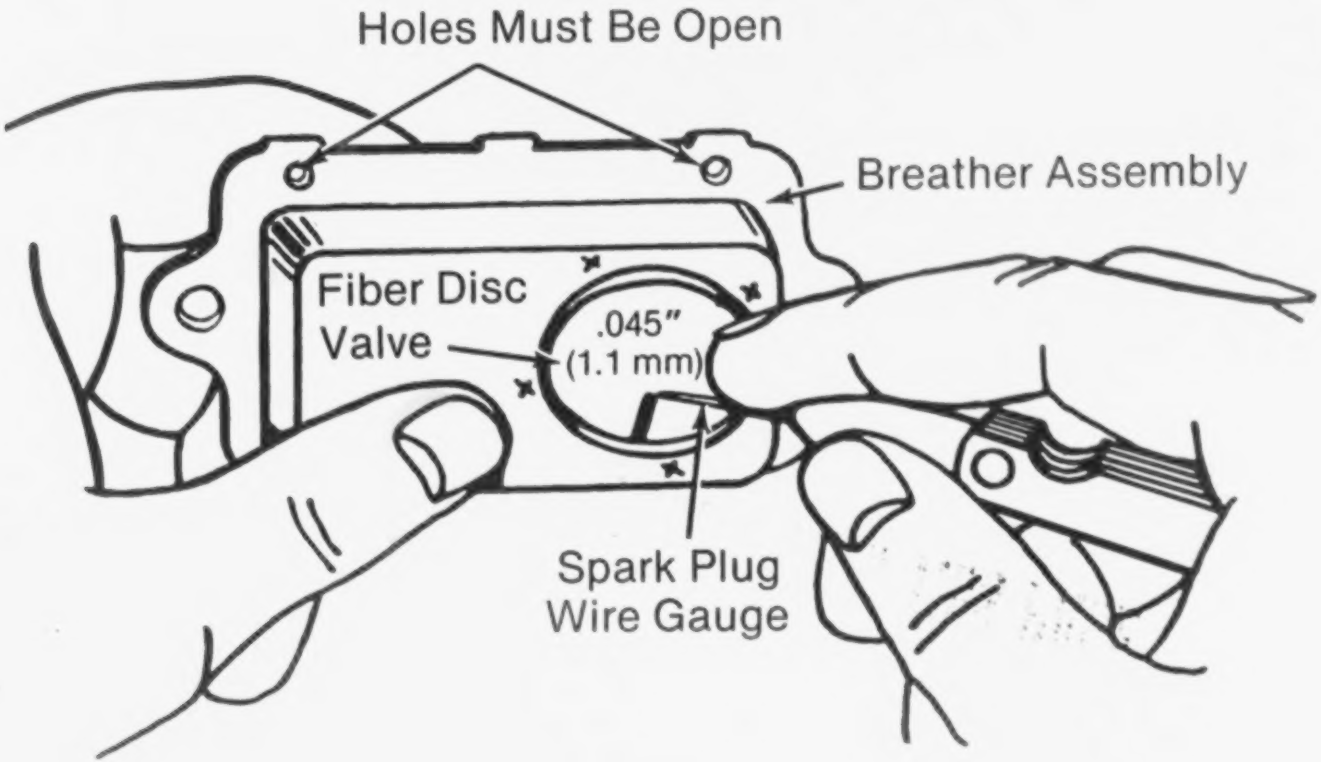

Cam Gear
Slinger



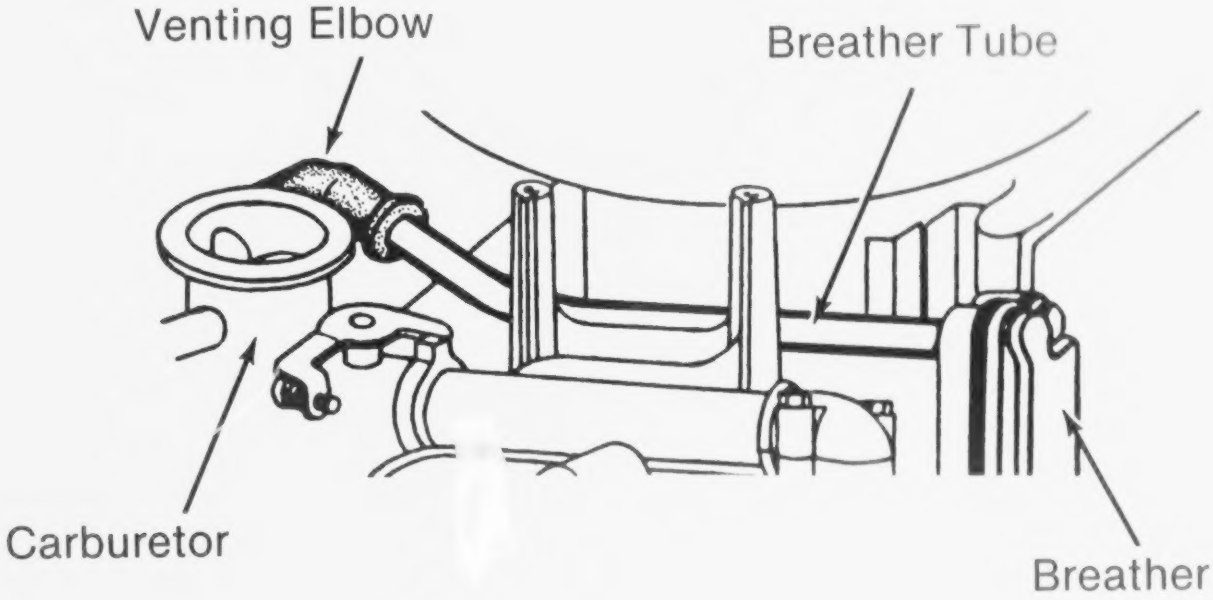
Dipper, Pump, and Constant-Level Sump


Connecting Rod
Pump
Constant-Level Sump
Dipper

Crankcase Breather

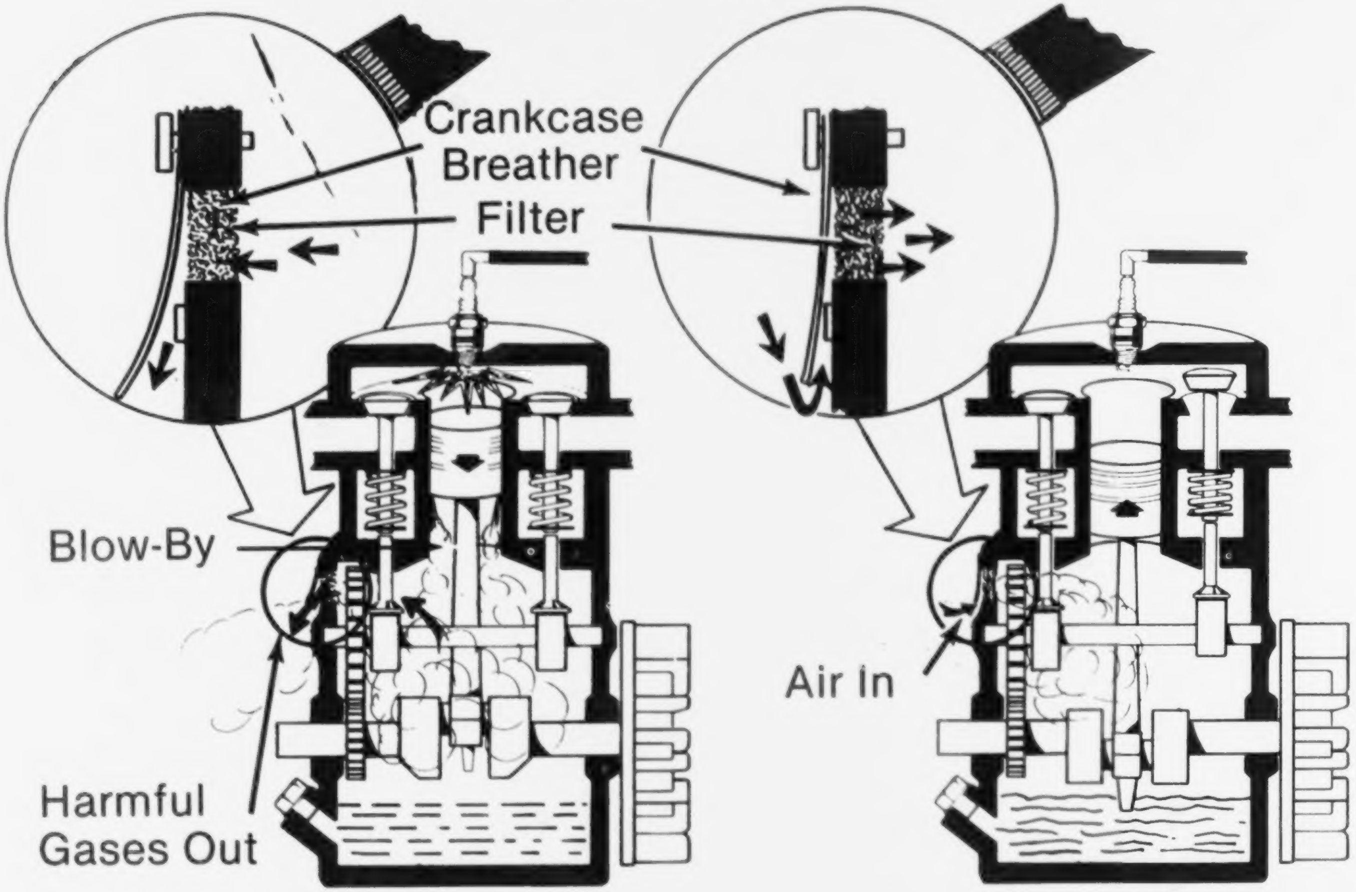

Holes Must Be Open
Breather Assembly
Fiber Disc Valve
.045"
(1.1 mm)
Spark Plug Wire Gauge

Crankcase Breather Vented To Carburetor

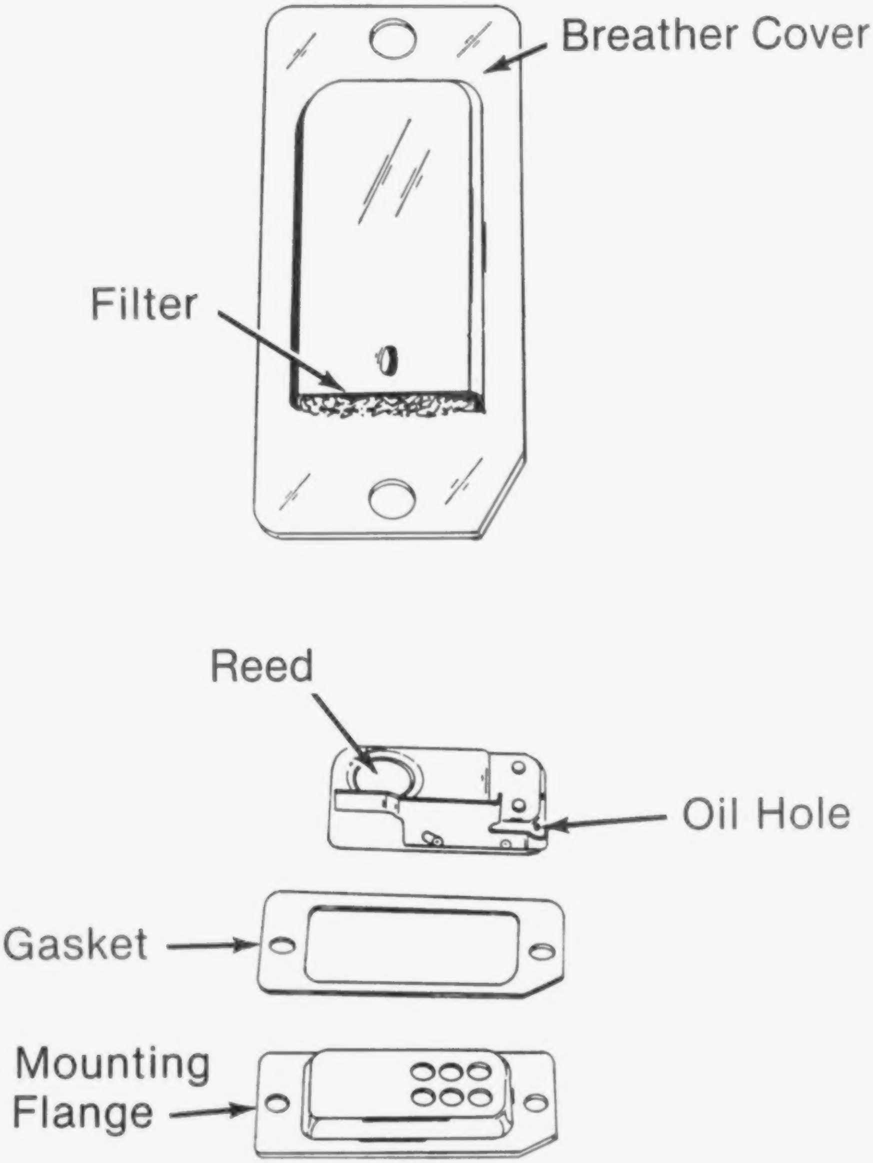

Venting Elbow
Breather Tube
Carburetor
Breather

Crankcase Breather Principles

(4 Cycle Engine)

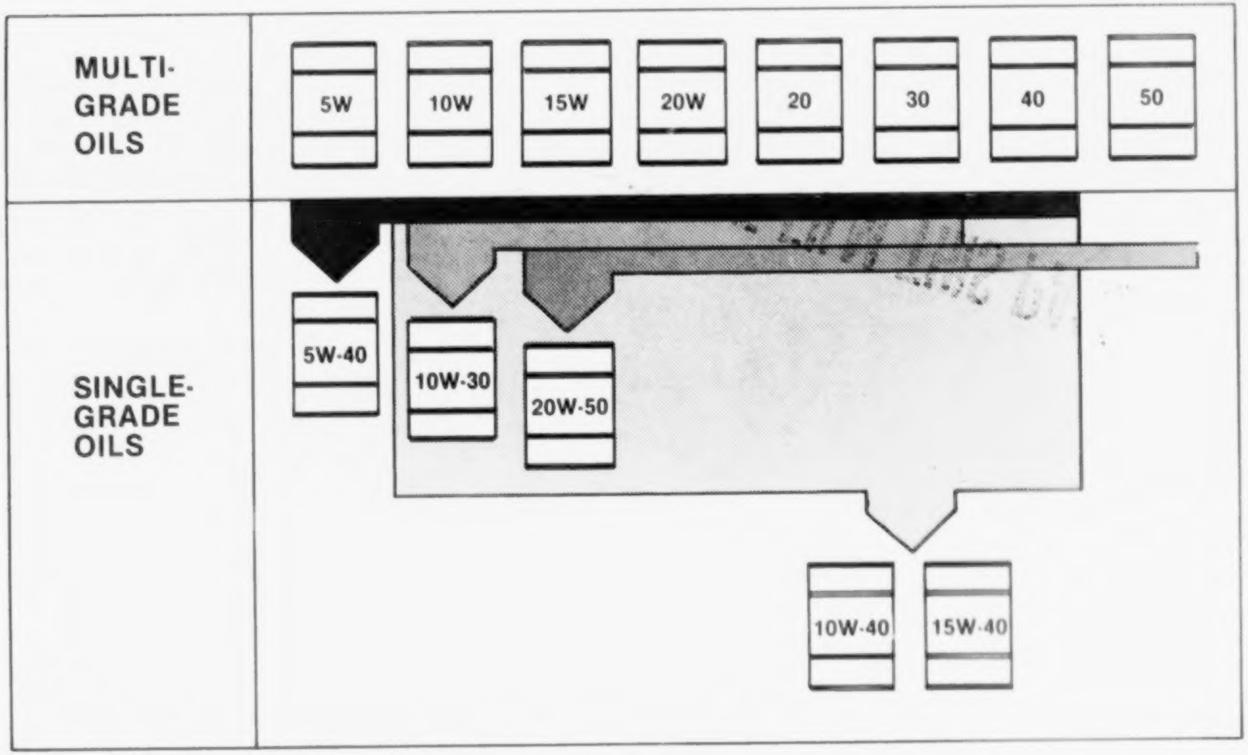

Crankcase
Breather
Filter
Blow-By
Harmful
Gases Out
Air In

A Typical Crankcase Breather


Breather Cover
Filter
Reed
Oil Hole
Gasket
Mounting Flange

Comparison of Crankcase Oils

(Viscosity-Grades)



MULTI-GRADE OILS

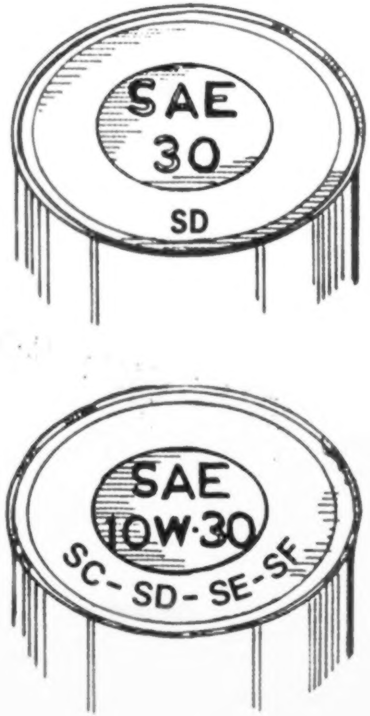
5W
10W
15W
20W
20
30
40
50

SINGLE-GRADE OILS

5W-40
10W-30
20W-50
10W-40
15W-40

API Classification System

(NOTE: Check operator's manual for recommended oil classification. Use a high quality detergent oil classified "For Service SC, SD, SE, or SF." Classification markings are on the oil can.)


SAE
30
SD
SAE
10W·30
SC-SD-SE-SF

LUBRICATION SYSTEMS
UNIT II-D

JOB SHEET #1 — CHANGE ENGINE OIL AND FILTER

A. Tools and materials needed

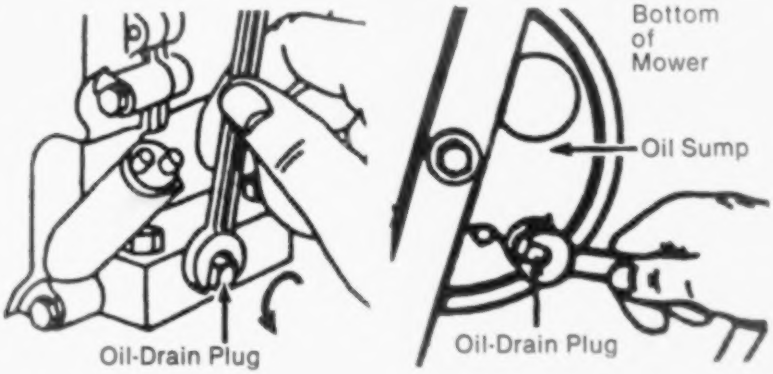
1. Drain pan
2. Wrench to fit drain plug
3. Oil can spout
4. Shop towels
5. Safety glasses

B. Procedure

1. Start engine and run to operating temperature
2. Disconnect spark plug wire and ground
3. Place drain pan under drain plug
4. Remove drain plug (Figure 1)

   (NOTE: Oil should be drained when hot.)

   FIGURE 1



5. Observe color and condition of oil

   (NOTE: Water and other contaminants might indicate problems in other areas.)

JOB SHEET #1

6. Allow oil plenty of time to drain completely

7. Change oil filter if required

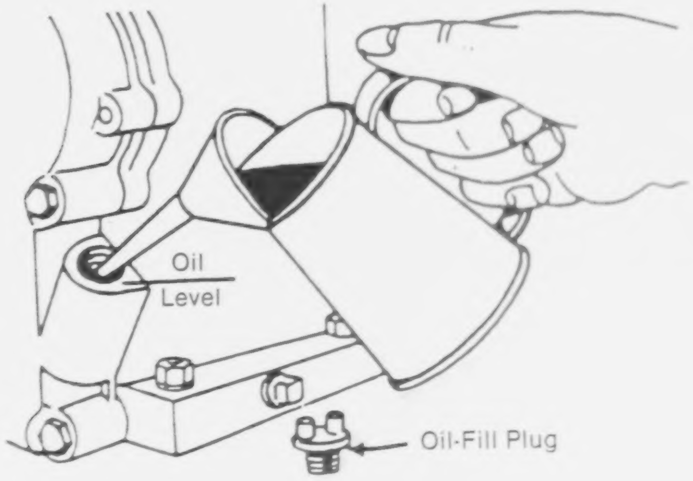
8. Replace drain plug

   (NOTE: Start with fingers and tighten adequately with wrench.)

9. Refill crankcase to recommended level with the proper engine oil (Figure 2)

   (NOTE: Be sure filler can and spout are clean.)

FIGURE 2



10. Clean and replace oil filler cap

11. Start engine and operate for a few minutes

12. Check for oil leaks

13. Shut off engine

14. Check oil level

    (NOTE: Add oil if needed. Do not overfill.)

15. Have instructor check work

16. Clean up work area and replace tools in proper area

LUBRICATION SYSTEMS
UNIT II-D

JOB SHEET #2 — SERVICE CRANKCASE BREATHER

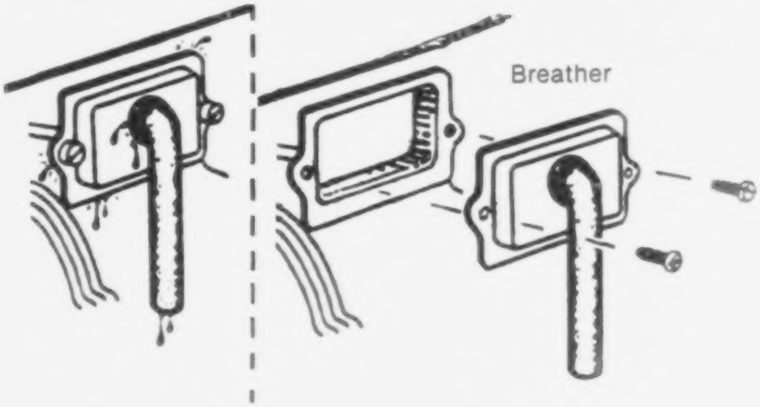
A. Tools and materials needed

1. Hand tool assortment
2. Clean towels
3. Solvent
4. Container for cleaning parts
5. New gasket
6. Feeler gauge
7. Safety glasses

B. Procedure

1. Disconnect spark plug wire and ground
2. Check breather for proper operation
3. Remove crankcase breather (Figure 1)

FIGURE 1

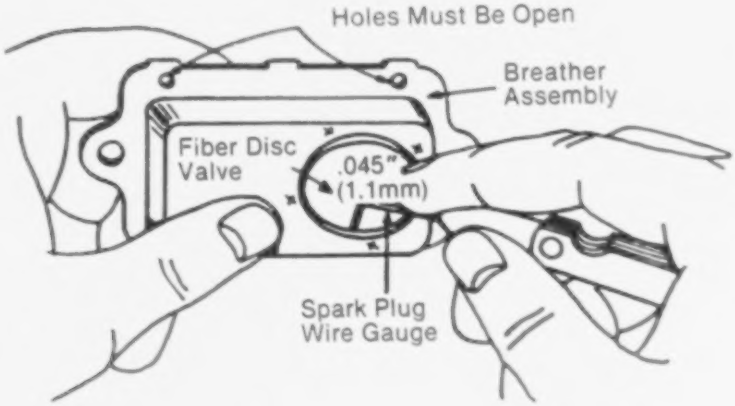


JOB SHEET #2

4. Check breather for proper clearance. If a .045 wire gauge will enter the space between fiber disc valve and body, a new breather should be installed (Figure 2)

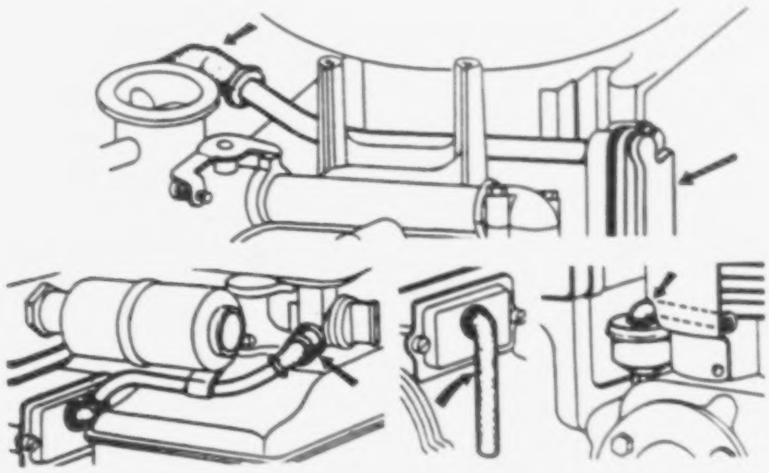
   (NOTE: Do not apply force when checking with wire gauge.)

   FIGURE 2


Holes Must Be Open
Breather Assembly
Fiber Disc Valve
.045"
(1.1mm)
Spark Plug Wire Gauge

5. Inspect venting elbows for loose fit and damaged tubes; replace if necessary (Figure 3)

   FIGURE 3



6. Clean parts in solvent

7. Dry breather with compressed air

8. Install breather using a new gasket

JOB SHEET #2

9. Run engine for a few minutes
10. Check breather for oil leaks
11. Stop engine
12. Have instructor check work
13. Clean work area and return tools to their proper place

LUBRICATION SYSTEMS
UNIT II-D

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

______a. Certain chemicals added to oil to provide extra performance

______b. Oils compounded to behave as light oils at cold temperatures and heavy oils at warm temperatures

______c. Society of Automotive Engineers

______d. American Petroleum Institute

______e. A measure of the fluidity of an oil at a given temperature

______f. Device rotated by the camshafts for splashing oil

______g. Cover on the bottom of the engine block providing a reservoir for the engine oil

______h. Passageways in the engine used to carry oil from one area to another

______i. Device allowing the oil pump to pick up oil which is free from sediment in the oil pan

______j. Device used to remove abrasive particles from the oil

______k. Device fastened to connecting rod as a means of splashing oil

______l. Valve in the lubrication system designed to limit maximum oil pressure

______m. Gases under pressure leaking by the piston rings during combustion and the power stroke

1. SAE
2. Viscosity
3. API
4. Multi-grade oil
5. Additives
6. Oil pan (sump)
7. Oil filter
8. Slinger
9. Pressure relief valve
10. Oil gally (passage)
11. Dipper
12. Oil pickup
13. "W" oils
14. Friction
15. Blow-by
16. Sludge

TEST

______n. Types of oils that are suitable for winter service

______o. Heavy, thick residue found in the bottom of an oil pan caused by oil deterioration or oil contamination

______p. Resistance to movement between two objects placed in contact with one another

2. Distinguish between two types of lubrication systems by placing an "X" next to the types of splash system.

______a. Barrell and plunger type; gear and rotor type

______b. Dipper type; slinger type

3. Select purposes of the crankcase breather by placing an "X" in the appropriate blanks.

______a. Cools engine parts

______b. Allows blow-by to escape

______c. Limits corrosion of engine parts

______d. Prevents oil leaks at seals and gaskets by relieving crankcase pressure

______e. Prevents entrance of fresh air

4. Match components of the crankcase breather on the right with their correct purposes.

______a. Keeps excessive oil from splashing onto filter

______b. Prevents entrance of excessive amounts of dirt

______c. Limits amount of fresh air entering crankcase and allows blow-by to leave engine

______d. Prevents dirt and abrasives from entering air

1. Cover (valve)
2. Filter
3. Baffle
4. Reed

5. Complete the following list of functions of engine oil by correctly filling in the blanks.

a. Reduces ______________________ and tear

b. ______________________ moving parts

c. Helps seal ______________________

d. Keeps parts ______________________

TEST

6. Select characteristics of a good engine oil by placing an "X" in the appropriate blanks.

______a. Keeps a protective film on moving parts

______b. Resists breakdown at high temperatures

______c. Resists corrosion and rusting

______d. Prevents carbon build-up

______e. Prevents sludge formation

______f. Flows easily at low temperature

______g. Flows easily at high temperatures

______h. Resists foaming

______i. Resists breakdown after long use

7. Complete the following list of statements concerning the SAE viscosity number by correctly filling in the blanks.

a. Oils vary in viscosity as ______________________ change

b. Lighter oils for winter use are specified at _____________ °F and carry a 5w, 10w, or 20w symbol

c. Heavier oils are specified at _____________ °F and carry a 20, 30, 40 or 50 viscosity number

8. Complete the following list of statements concerning the API oil classification system by circling the correct words.

a. Standardized specifications for oil qualities between the engine manufacturer, the petroleum industry, and the **(dealer, customer)**

b. Four service classifications found on oil cans include

1) **(SC, SD)** — Oil meeting the 1964-67 warranty requirements of automobile manufacturing

2) **(SC, SD)** — Oil meeting the 1968-1971 warranty requirements

3) SE — Oil meeting the **(1972-1979, 1980)** warranty requirements

4) SF — Oil meeting the **(1980, 1972-1979)** warranty requirements

TEST

9. List four oil contaminants.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

10. Match the oil additives on the right with their correct functions.

______a. Helps prevent failure of alloy bearings from corrosive acids caused by combustion

______b. Prevents acid, varnish, and sludge formations

______c. Prevents rusting of metal parts during storage or downtime

______d. Helps oil give top lubricating protection at both high and low temperatures

______e. Prevents wax crystals from congealing in cold weather and forming clumps

______f. Assures lubrication where extreme pressures between close tolerances are encountered

______g. Helps keep metal surfaces clean and prevents deposit formation

______h. Helps prevent air bubbles which would restrict lubrication

1. Anti-rust
2. Oxidation inhibitor
3. Anti-corrosion
4. Viscosity index improver
5. Pour point depressant
6. Extreme pressure
7. Foam inhibitor
8. Detergent-dispersant

11. Select factual statements about oil by placing an "X" in the appropriate blanks.

______a. Oil becomes unfit for further use as it absorbs contaminants and as additives are depleted

______b. Multi-viscosity oils are not always preferred

______c. Black oil does not mean time for an oil change

______d. Buy quality oil filters as recommended by machine operator's manual

______e. Oil oxidation results in thicker oil

TEST

_____f. Using a light oil until consumption increases, and then switching to a heavier oil, is not a good practice

_____g. Following operator's manual recommendations is critical to insure good performance

12. Complete the following list of statements concerning the selection and use of oils for best engine performance by correctly filling in the blanks.

a. Use brands which meet engine ____________________ specifications

b. ____________________ and change at recommended intervals

c. Select oils which have been ____________________

d. Never mix oils of various ____________________

e. Bring engine up to normal operating ____________________ each time it is used

f. Use clean oil containers and keep covered, sealed, and protected to prevent ____________________

g. Replace or clean filters before they become ____________________

13. Select true statements concerning two cycle oil selection and use by placing an "X" in the appropriate blanks.

a. Selection

_____1) Select only manufacturer's recommended rating

_____2) Select only oil recommended for use in either air cooled or water cooled two cycle engines

b. Use

_____1) Use oil-fuel mixture recommended by manufacturer

_____2) Use oils that are **close to** manufacturer's recommendations

_____3) Never mix synthetic oils with mineral oils

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

14. Demonstrate the ability to:

a. Change engine oil and filter (Job Sheet #1).

b. Service crankcase breather (Job Sheet #2).

LUBRICATION SYSTEMS
UNIT II-D

ANSWERS TO TEST

1. a. 5
   b. 4
   c. 1
   d. 3
   e. 2
   f. 8
   g. 6
   h. 10
   i. 12
   j. 7
   k. 11
   l. 9
   m. 15
   n. 13
   o. 16
   p. 14

2. b

3. b,c,d

4. a. 3
   b. 1
   c. 4
   d. 2

5. a. Friction
   b. Cools or cushions
   c. Cylinders
   d. Clean

6. a,b,c,d,e,f,h,i

7. a. Temperatures
   b. 0°F
   c. 210°F

8. a. Customer
   b. 1) SC
      2) SD
      3) 1972-1979
      4) 1980

9. Any six of the following:
   a. Foreign particles
   b. Water
   c. Antifreeze
   d. Fuel
   e. Oxidation
   f. Acids

ANSWERS TO TEST

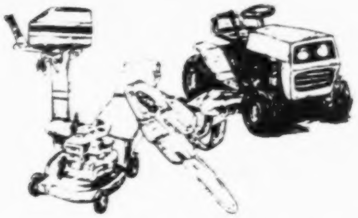
10. a. 3
    b. 2
    c. 1
    d. 4
    e. 5
    f. 6
    g. 8
    h. 7

11. All are correct

12. a. Manufacturer's
    b. Drain
    c. Performance tested
    d. Specifications
    e. Temperature
    f. Contamination
    g. Plugged

13. a. 1,2
    b. 1,3

14. Performance skills evaluated according to standards identified by the instructor



Cooling Systems
Unit III-D

UNIT OBJECTIVE

After completion of this unit, the student should be able to remove, clean, and replace air cooling parts. Competencies will be demonstrated by correctly performing the procedure outlined in the job sheet and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to cooling systems with their correct definitions.
2. List three functions of the cooling system.
3. Identify components of the cooling system.
4. Match components of the cooling system with their correct functions.
5. List two causes of overheating.
6. Demonstrate the ability to remove, clean, and replace air cooling parts (Job Sheet #1).

COOLING SYSTEMS
UNIT III-D

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparency.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparency to enhance the information as needed.)

G. Provide students with job sheet prior to the demonstration of the procedure.

H. Integrate the following activities throughout the teaching of this unit:

1. Demonstrate types of cooling systems found on engine.
2. Identify components on live engines, then test students on their ability to identify them.
3. Take students on a field trip to a radiator shop.
4. Measure air temperature off top of radiator to show how cooling system works.
5. Demonstrate and discuss the procedure outlined in the job sheet.
6. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

SUGGESTED ACTIVITIES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency Master 1 — Parts of a Cooling System

E. Job Sheet #1 — Remove, Clean, and Replace Air Cooling Parts

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Small Engines, Volume I.* Athens, Georgia: American Association for Vocational Instructional Materials.

B. Roth, Alfred C. *Small Gas Engines.* South Holland, Illinois: Goodheart-Willcox Co., Inc., 1975.

C. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

COOLING SYSTEMS
UNIT III-D

INFORMATION SHEET

I. **Terms and definitions**

   A. Conduction — Heat transfer through a solid material

   B. Convection — Heat transfer through movement of a gas

   (NOTE: In cooling systems, transfer is through air.)

   C. Shroud — Cover over blower (flywheel) that directs air to the engine fins

   D. Baffle — Cover over the finned area of the engine to hold the air around the fins

   E. Fin — Protrusions cast on the head and cylinder to provide increased surface for additional cooling area

   F. Cooling system — Components designed to keep the engine at its most efficient operating temperature during engine operation

II. **Functions of the cooling system**

   A. Removes surplus or unwanted heat

   B. Maintains efficient operating temperature under all operating conditions

   C. Brings an engine, when started, up to operating temperature as soon as possible

III. **Components of the cooling system (Transparency 1)**

   A. Flywheel

   B. Filter screen

   C. Blower shroud

   D. Cylinder head baffle

   E. Cylinder baffle

   F. Air deflector

INFORMATION SHEET

IV. **Components of the cooling system and their functions**

  A. Flywheel — Device used to move a large volume of air to the engine

  B. Filter screen — Covering on outside of flywheel to filter out large materials in the air stream

  (NOTE: These are such materials as leaves and grass.)

  C. Shroud and baffles — Covers flywheel and directs air over the engine fins to promote cooling

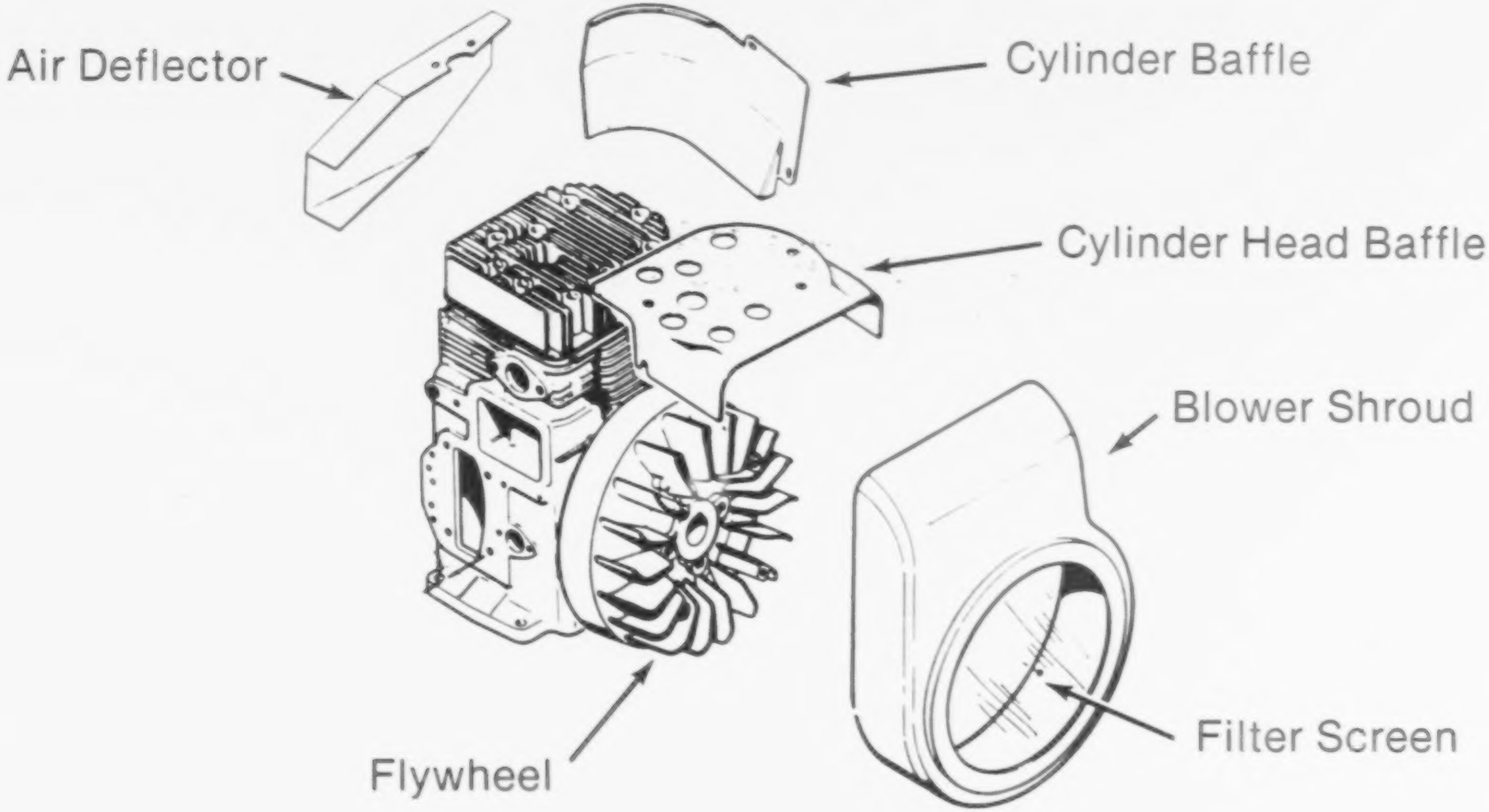
  D. Air deflector — Routes the air to cool the engine

V. **Causes of overheating**

  A. Improper timing

  B. Grime, grease, or oil on the outside of the engine

Parts of a Cooling System


Air Deflector
Cylinder Baffle
Cylinder Head Baffle
Blower Shroud
Filter Screen
Flywheel

COOLING SYSTEMS
UNIT III-D

JOB SHEET #1 — REMOVE, CLEAN, AND REPLACE AIR COOLING PARTS

A. Tools and materials needed

1. Hand tool assortment
2. Wire brush
3. Parts scraper
4. Wooden scraper
5. Cleaning solvent
6. Parts cleaning brush
7. Small hand sprayer
8. Safety glasses
9. Water hose
10. Compressed air

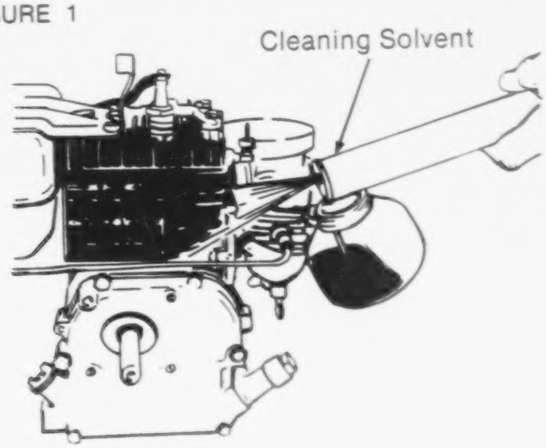
B. Procedure

1. Remove blower shroud
2. Remove baffles
3. Pour solvent into sprayer

JOB SHEET #1

4. Spray solvent over dirty fins and block areas (Figure 1)

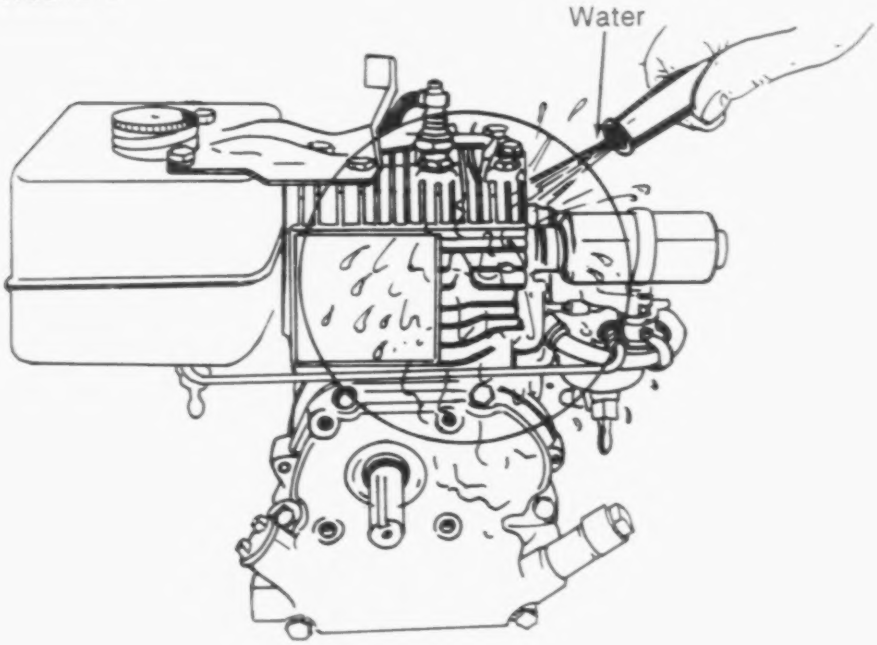
FIGURE 1


Cleaning Solvent

(NOTE: Let solvent soak long enough to loosen caked or dried dirt or grease.)

5. Wash engine with clear water (Figure 2)

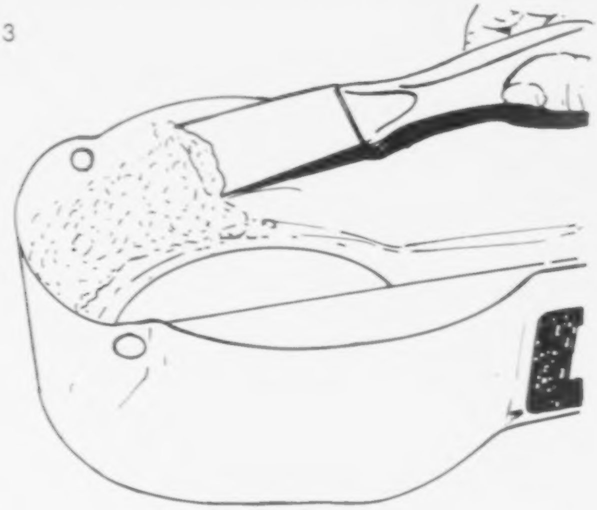
FIGURE 2



JOB SHEET #1

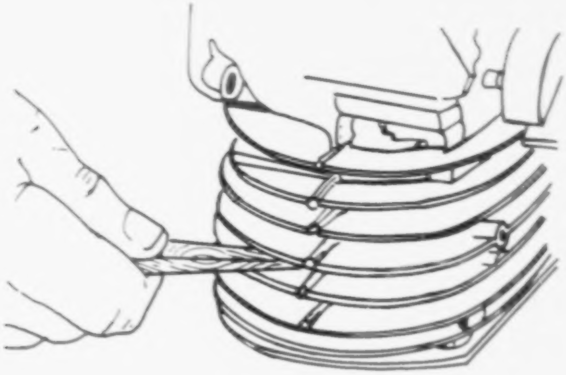
6. Scrape areas that have hard to remove accumulations of dirt or grease (Figures 3 and 4)

FIGURE 3



(NOTE: Use wooden scrapers on aluminum areas like newer engine blocks and fins.)

FIGURE 4



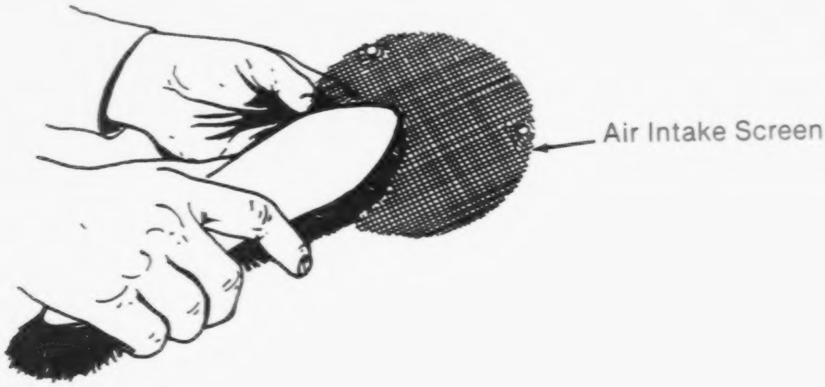
JOB SHEET #1

7. Clean flywheel fins

   (NOTE: Replace if necessary.)

8. Clean air intake screen with parts cleaning brush (Figure 5)

FIGURE 5



9. Dry engine with compressed air
10. Inspect all baffles, shroud, and screen for damage
11. Reassemble cooling system

    (NOTE: Do not alter the shroud.)

12. Have instructor evaluate your work

COOLING SYSTEMS
UNIT III-D

NAME ________________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. Heat transfer through a solid material

_____b. Cover over the finned area of the engine to hold the air around the fins

_____c. Protrusions cast on the head and cylinder to provide increased surface for additional cooling area

_____d. Cover over blower (flywheel) that directs air to the engine fins

_____e. Heat transfer through movement of a gas

_____f. Components designed to keep the engine at its most efficient operating temperature during engine operation

1. Fin
2. Baffle
3. Conduction
4. Convection
5. Cooling system
6. Shroud

2. List three functions of the cooling system.

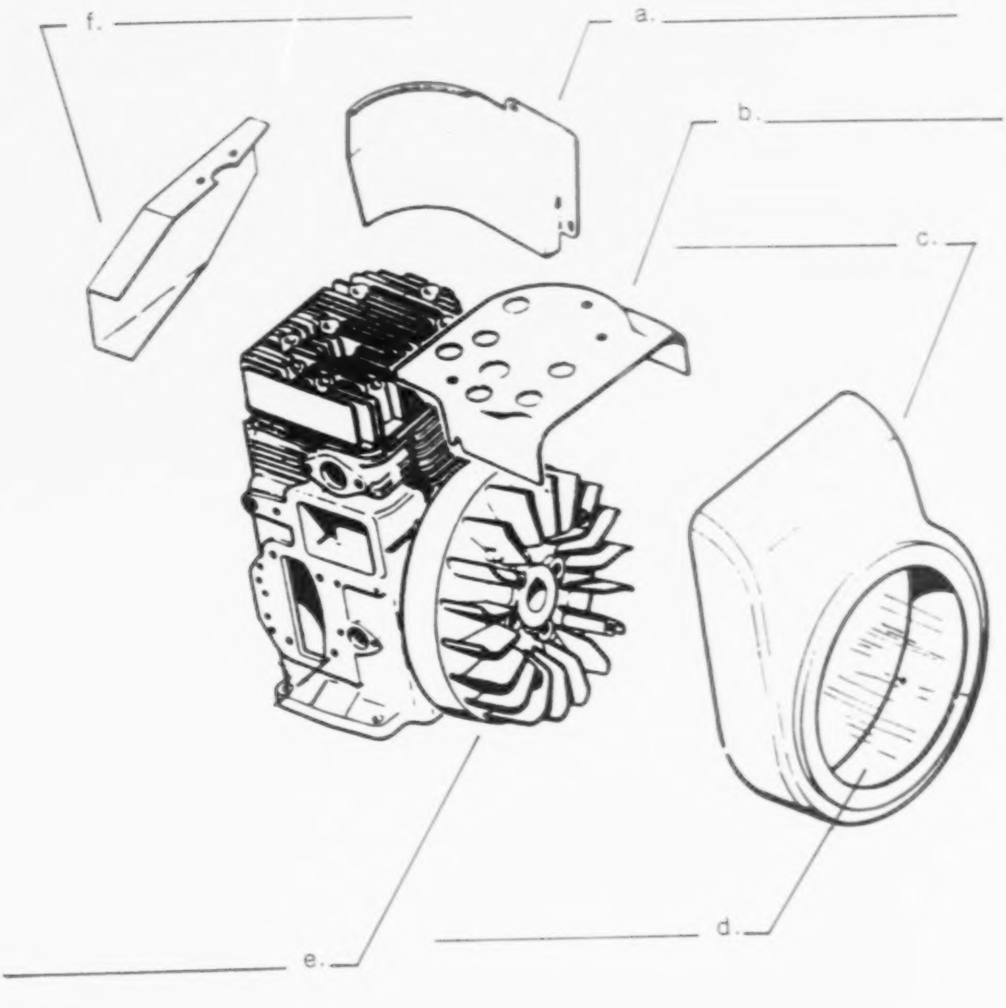
a. ____

b. ____

c. ____

TEST

3. Identify the components of the cooling system.



TEST

4. Match the components of the cooling system on the right with their correct functions.

_____a. Device used to move a large volume of air to the engine

_____b. Covering on outside of flywheel to filter out large materials in the air stream

_____c. Covers flywheel and directs air over the engine fins to promote cooling

_____d. Routes the air to cool the engine

1. Shroud and baffles
2. Air deflector
3. Flywheel
4. Filter screen

5. List two causes of overheating.

a. ____

b. ____

(NOTE: If the following activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

6. Demonstrate the ability to remove, clean, and replace air cooling parts (Job Sheet #1).

COOLING SYSTEMS
UNIT III-D

ANSWERS TO TEST

1. a. 3
   b. 2
   c. 1
   d. 6
   e. 4
   f. 5

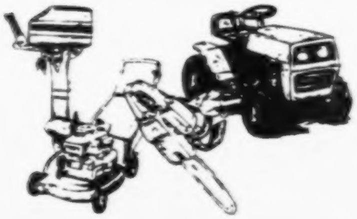
2. a. Removes surplus or unwanted heat
   b. Maintains efficient operating temperature under all operating conditions
   c. Brings an engine, when started, up to operating temperatures as soon as possible

3. a. Cylinder baffle
   b. Cylinder head baffle
   c. Blower shroud
   d. Filter screen
   e. Flywheel
   f. Air deflector

4. a. 3
   b. 4
   c. 1
   d. 2

5. a. Improper timing
   b. Grime, grease, or oil on the outside of the engine

6. Performance skills evaluated according to the standards identified by the instructor



Fuel Systems
Unit IV-D

UNIT OBJECTIVE

After completion of this unit, the student should be able to remove, replace, and service a carburetor and a fuel pump and service an air cleaner. Competencies will be demonstrated by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to the fuel system with their correct definitions.
2. State the purpose of the fuel system.
3. List the three basic types of small engine fuel supply systems.
4. Match components of the fuel system with their correct functions.
5. List the two types of carburetors.
6. Select types of fuel filters.
7. Distinguish between types of fuel pump action.
8. Identify three types of air cleaners.
9. Identify parts of the float-type carburetor.
10. Identify parts of the diaphragm-type carburetor.

OBJECTIVE SHEET

11. Match the carburetor systems with their correct uses.

12. Demonstrate the ability to:

    a. Service an air cleaner (Job Sheet #1).

    b. Remove and replace a float-type carburetor (Job Sheet #2).

    c. Service a float-type carburetor (Job Sheet #3).

    d. Remove, service, and replace a diaphragm-type carburetor (Job Sheet #4).

    e. Remove and replace a fuel pump (Job Sheet #5).

    f. Test and service a fuel pump (Job Sheet #6).

    g. Service sediment bowl fuel strainer (Job Sheet #7).

FUEL SYSTEMS
UNIT IV-D

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets prior to the demonstration of the procedures.

H. Integrate the following activities throughout the teaching of this unit:

  1. Show worn or damaged carburetor parts.
  2. Collect gasoline samples in baby food jars from various stations and compare quality. Look for residue at bottom of jars.
  3. Demonstrate and discuss the procedures outlined in the job sheets.
  4. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

SUGGESTED ACTIVITIES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

1. TM 1 — Fuel Supply Systems
2. TM 2 — Fuel Filter — (Filter Attached to End of Flexible Fuel Hose)
3. TM 3 — Fuel Filter — (Glass Sediment Bowl and Screen)
4. TM 4 — Fuel Filter — (Screen In Tank)
5. TM 5 — Fuel Filter — (In-Line)
6. TM 6 — Fuel Pump
7. TM 7 — Operation of Fuel Pump
8. TM 8 — Types of Air Cleaners
9. TM 9 — Parts of a Float Carburetor
10. TM 10 — Parts of a Diaphragm Carburetor
11. TM 11 — The Float System
12. TM 12 — Float-Type Carburetor
13. TM 13 — Carburetor Choke Valve
14. TM 14 — The Choke System
15. TM 15 — The High Speed System
16. TM 16 — The Idle System
17. TM 17 — Bulb-Type Primer

E. Job sheets

1. Job Sheet #1 — Service an Air Cleaner
2. Job Sheet #2 — Remove and Replace a Float-Type Carburetor
3. Job Sheet #3 — Service a Float-Type Carburetor

SUGGESTED ACTIVITIES

4. Job Sheet #4 — Remove, Service, and Replace a Diaphragm-Type Carburetor
5. Job Sheet #5 — Remove and Replace a Fuel Pump
6. Job Sheet #6 — Test and Service a Fuel Pump
7. Job Sheet #7 — Service Sediment Bowl Fuel Strainer

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Roth, Alfred C. *Small Gas Engines*. South Holland, Illinois: Goodheart-Willcox Co., Inc., 1975.

B. Hendrix, Laborn. *Cement Masonry*. Stillwater, Oklahoma: Curriculum and Instructional Materials Center/State Department of Vocational and Technical Education and Associated General Contractors, 1974.

C. Herd, Amon. *Carburetor Service and Repair*. Columbia, Missouri: Instructional Materials Laboratory, University of Missouri-Columbia.

D. *Comprehensive Small Engine Repair*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

FUEL SYSTEMS
UNIT IV-D

INFORMATION SHEET

I. **Terms and definitions**

   A. Venturi — Restriction in the carburetor which makes the air speed up, causing a high vacuum

   B. Airfoil — Tube in a stream of air inside the venturi which creates an air pattern with low pressure on one side

   C. Atomization — Breaking of a liquid into tiny particles or globules to aid vapor formation

   D. Metering — Correct proportion of fuel and air needed for good combustion

   E. Vaporization — Transferring a substance into a gaseous state

II. **Purpose of the fuel system —** The fuel system supplies a combustible mixture of air and fuel vapor to the engine cylinder(s)

III. **Basic types of small engine fuel supply systems** (Transparency 1)

   A. Gravity feed

   B. Suction feed

   C. Pump feed

IV. **Components of the fuel system**

   A. Fuel tank — Acts as reservoir to store fuel for engine use

   B. Fuel filter — Prevents dirt or foreign matter from entering the carburetor

   C. Carburetor — Mixes fuel and air in the proper proportion for a combustible mixture

   D. Fuel pump — Pumps fuel from the fuel tank to the carburetor

   E. Fuel line — Carries fuel from the fuel tank to the carburetor

   F. Air cleaner — Filters grit and dust from the air entering the carburetor

   G. Pump diaphragm — Sheet of metal or other material that is sufficiently flexible to permit vibration

   (NOTE: The diaphragm is housed in the pump.)

INFORMATION SHEET

V. **Types of carburetors**

  A. Float

  B. Diaphragm

VI. **Types of fuel filters** (Transparencies 2, 3, 4 and 5)

  A. Glass sediment bowl and screen

  B. Screen in fuel tank

  C. Filter attached to the end of flexible fuel hose (in tank)

  D. In-Line filter

VII. **Fuel pump action** (Transparencies 6 and 7)

  A. Inlet stroke

    1. Diaphragm flexes downward, forming a vacuum

    2. Inlet check valve opens

    3. Fuel is drawn into pump

  B. Outlet stroke

    1. Diaphragm pushed upward by return spring

    2. Inlet valve forced shut

    3. Outlet valve forced open

    4. Fuel is forced out of pump

VIII. **Types of air cleaners** (Transparency 8)

  A. Oil bath

  B. Paper element

  C. Polyurethane

  (NOTE: Some systems use a dual element filter.)

IX. **Parts of the float-type carburetor** (Transparency 9)

  A. Fuel inlet

  B. Float needle seat

  C. Float needle

INFORMATION SHEET

- D. Nozzle
- E. Packing nut
- F. Needle valve
- G. Float
- H. Throttle valve
- I. Idle valve
- J. Venturi
- K. Choke valve

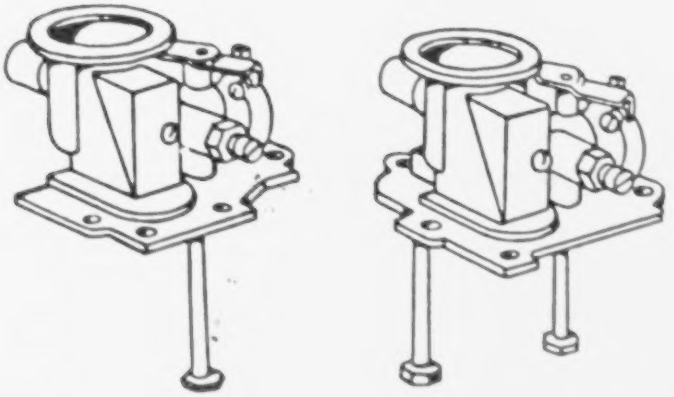
X. **Parts of the diaphragm-type carburetor** (Transparency 10)

- A. Needle valve
- B. Speed adjusting screw
- C. Idle adjusting screw
- D. Choke
- E. Pump cover
- F. Fuel pipes
- G. Spring and cap
- H. Diaphragm

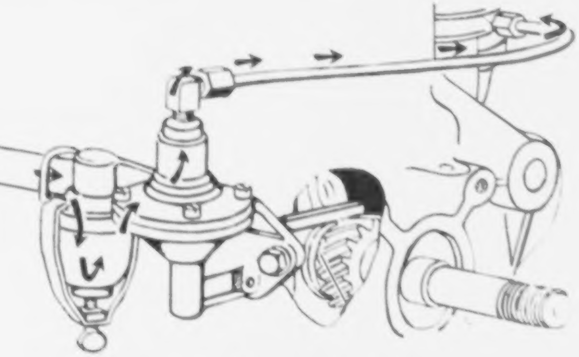
XI. **Carburetor systems** (Transparencies 11, 12, 13, 14, 15, 16 and 17)

- A. Float — Maintains a given depth of fuel in the float chamber
- B. Choke — Provides a richer mixture for cold engine starting and operation
- C. High speed — Used when the engine is called upon to supply power for full, partial, or no-load at various operating speeds
- D. Idle speed — Provides fuel delivery during closed or nearly closed throttle operation
- E. Throttle — Regulates the amount of air/fuel mix allowed to enter the engine

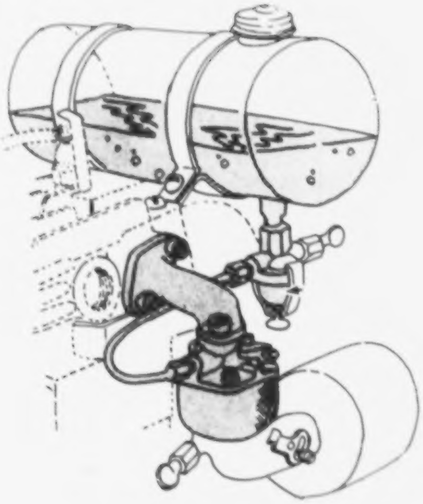
Fuel Suppy Systems



Suction Feed System

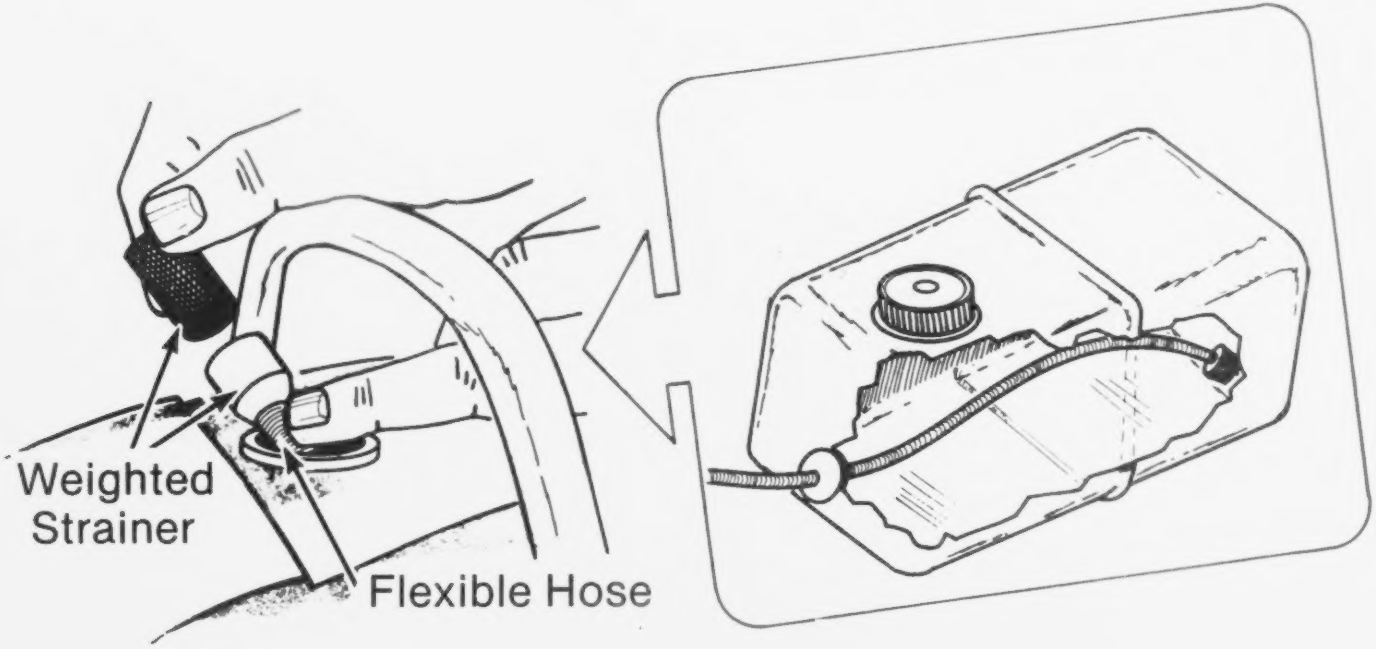


Pump Feed System



Gravity Feed System

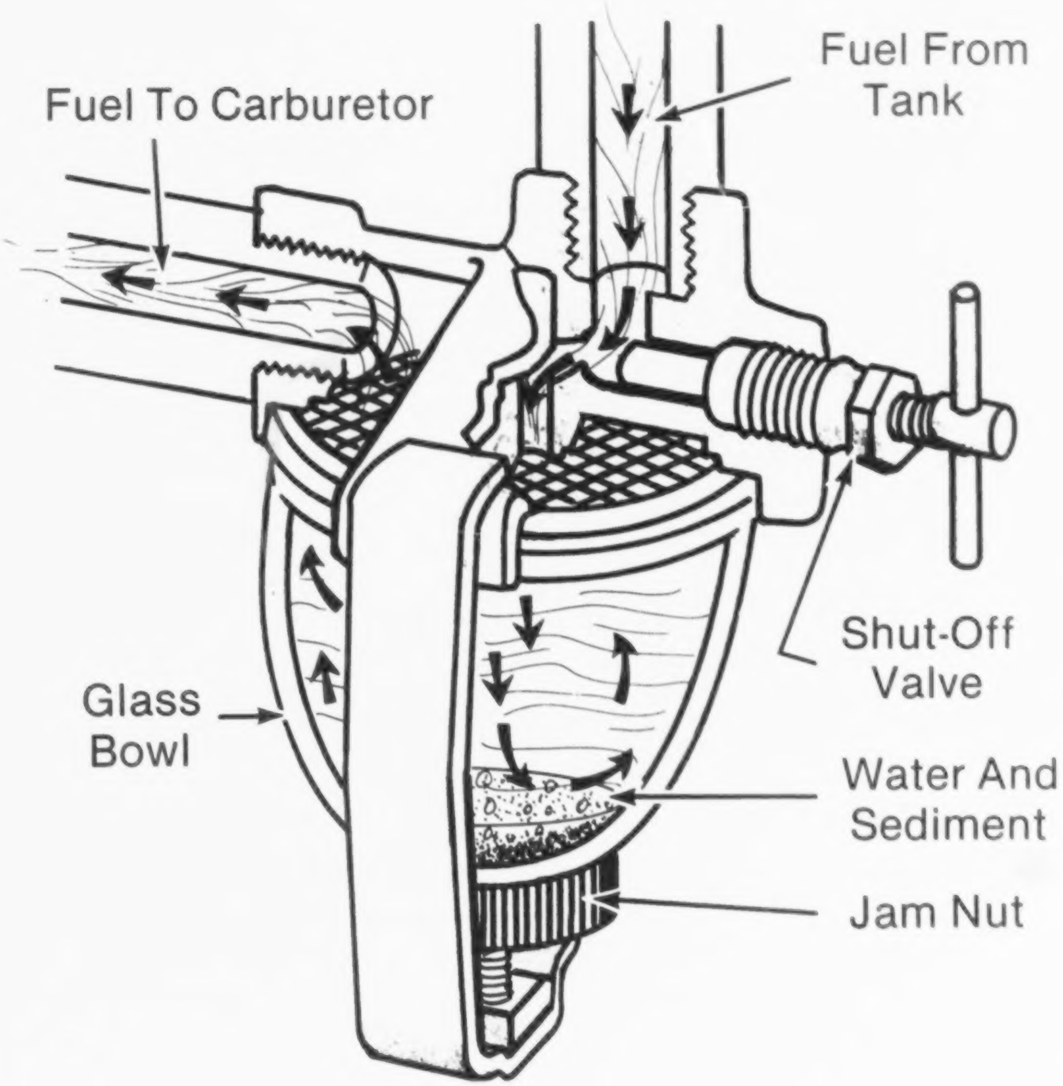
Fuel Filter


Weighted Strainer
Flexible Hose

Filter attached to end of flexible fuel hose.

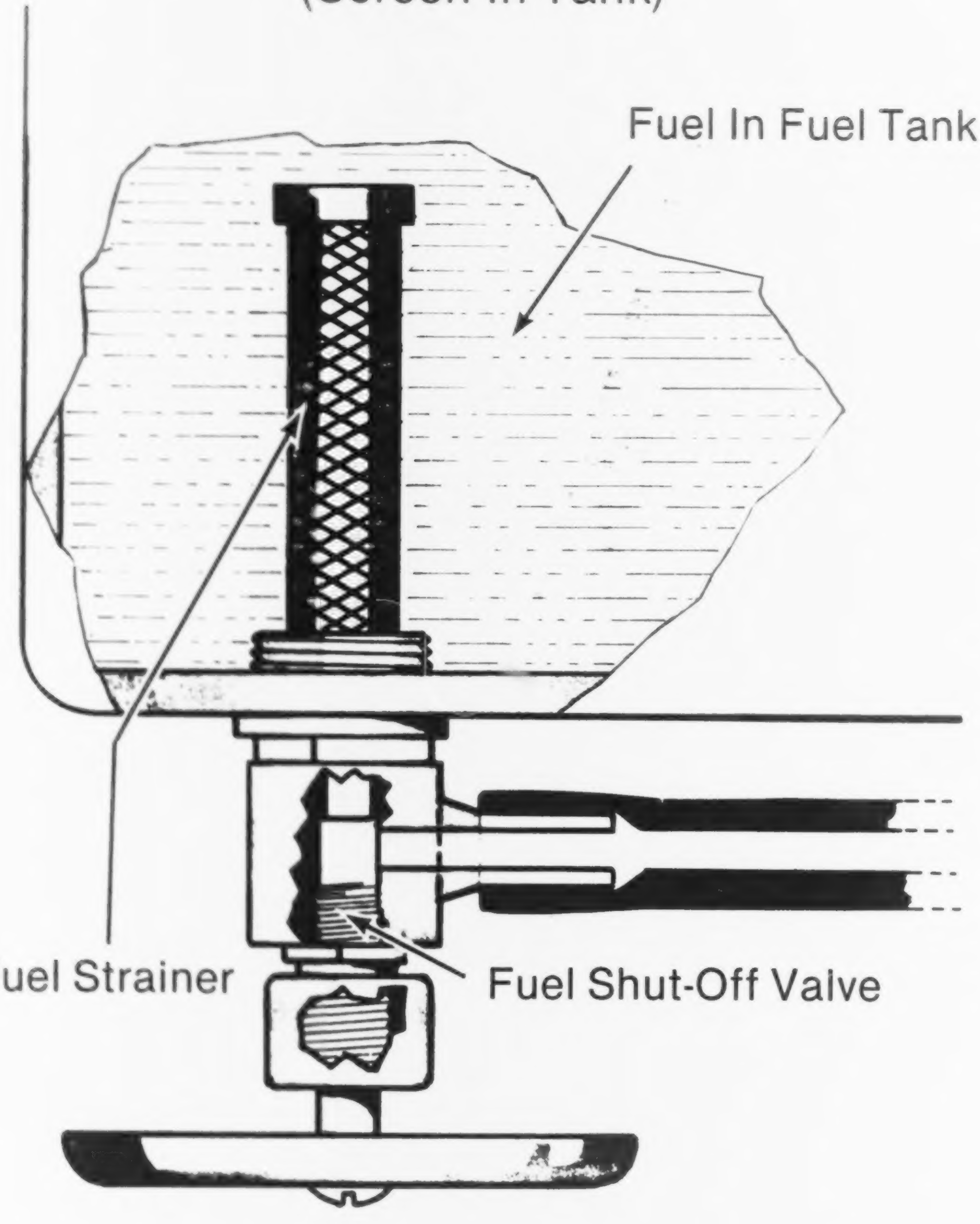
Fuel Filter

(Glass Sediment Bowl And Screen)

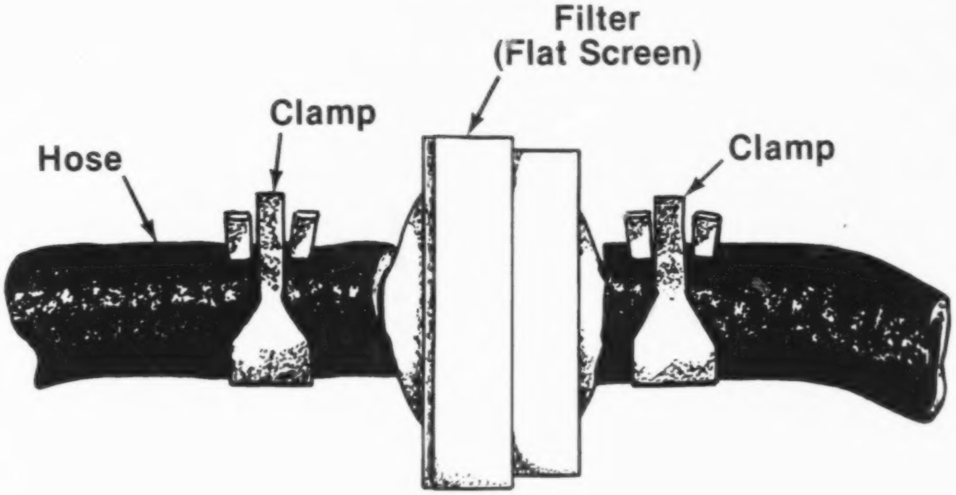

Fuel To Carburetor
Fuel From Tank
Shut-Off Valve
Glass Bowl
Water And Sediment
Jam Nut

Fuel Filter

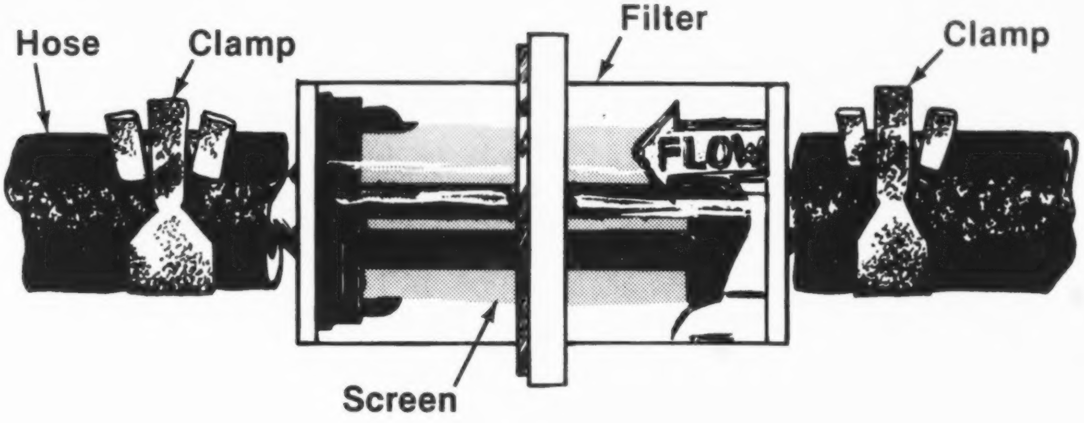
(Screen In Tank)


Fuel In Fuel Tank
Fuel Strainer
Fuel Shut-Off Valve

Fuel Filter
(In-Line)

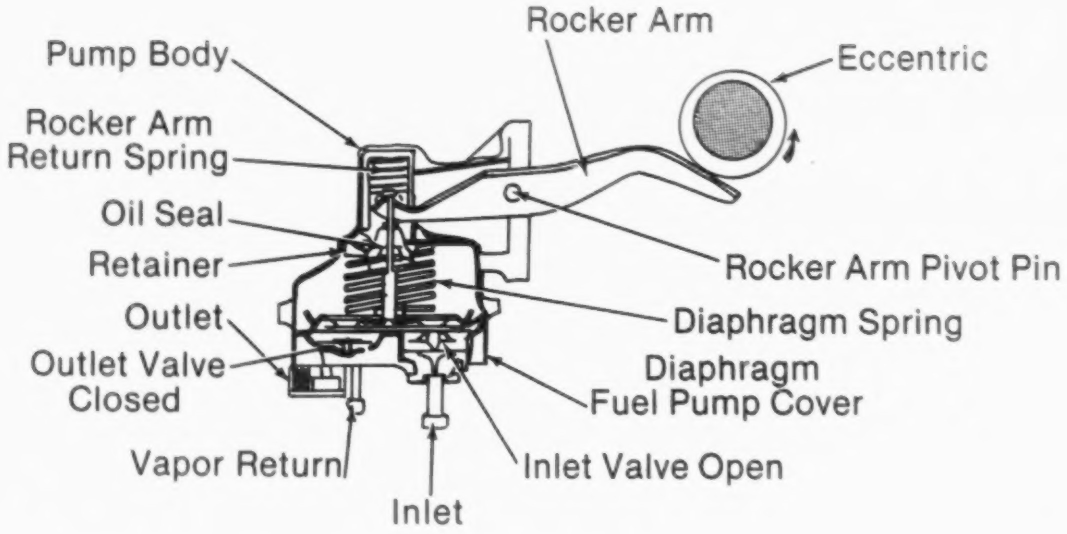

Filter
(Flat Screen)
Clamp
Hose
Clamp

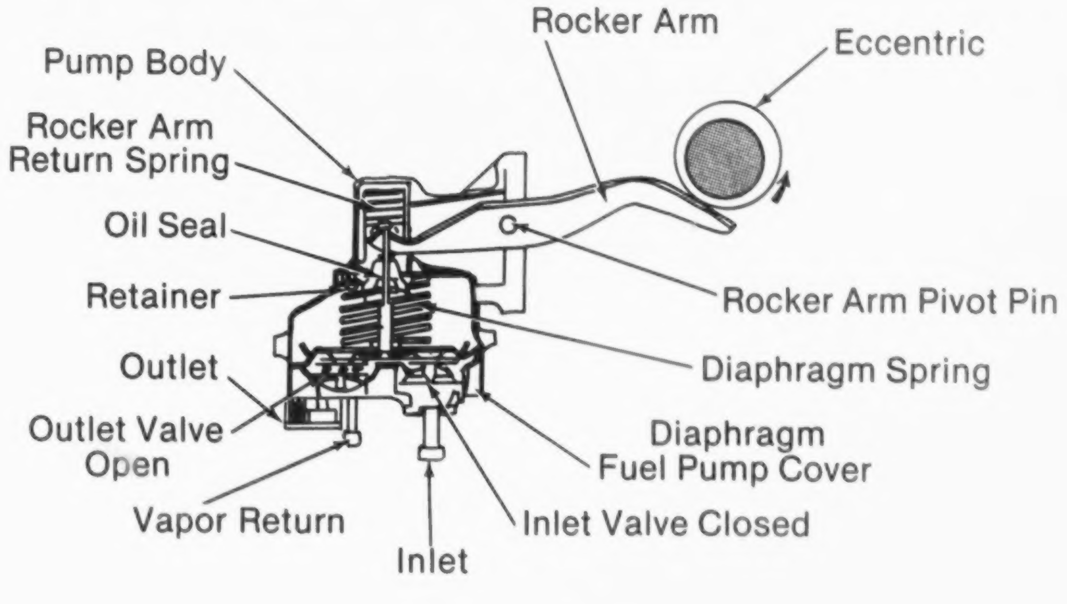
(NOTE: This is a diagram of a Briggs and Stratton in-line filter.)


Hose
Clamp
Filter
Clamp
FLOW
Screen

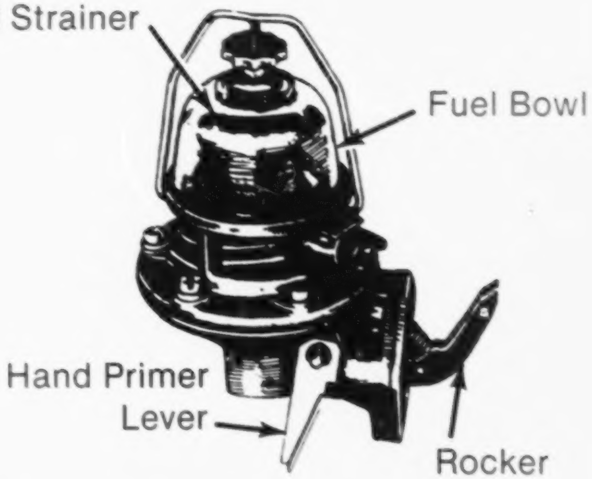
(NOTE: This is a diagram of a Whelbro in-line filter.)

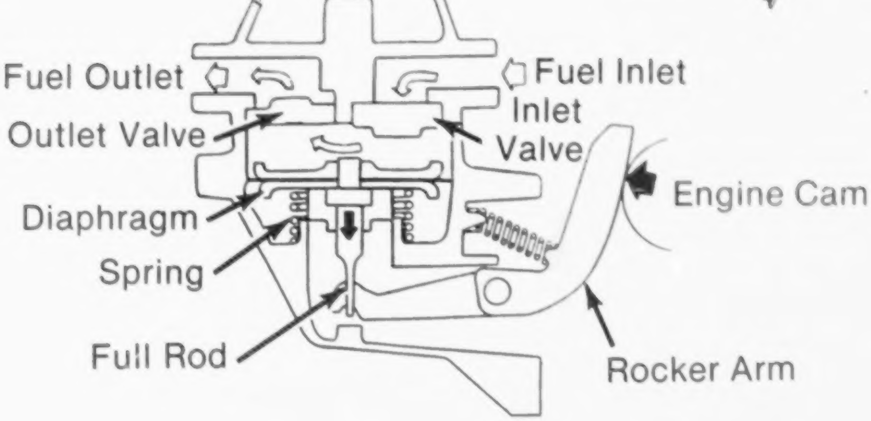
Fuel Pump


Rocker Arm
Eccentric
Pump Body
Rocker Arm Return Spring
Oil Seal
Retainer
Outlet
Outlet Valve Closed
Vapor Return
Inlet
Inlet Valve Open
Diaphragm Fuel Pump Cover
Diaphragm Spring
Rocker Arm Pivot Pin

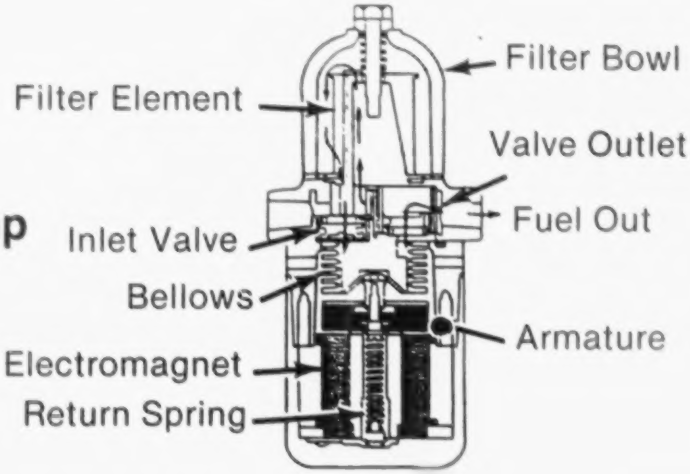

Rocker Arm
Eccentric
Pump Body
Rocker Arm Return Spring
Oil Seal
Retainer
Outlet
Outlet Valve Open
Vapor Return
Inlet
Inlet Valve Closed
Diaphragm Fuel Pump Cover
Diaphragm Spring
Rocker Arm Pivot Pin

Operation of Fuel Pump


Fuel Strainer
Fuel Bowl
Hand Primer
Lever
Rocker
Arm


Fuel Outlet
Fuel Inlet
Outlet Valve
Inlet
Valve
Engine Cam
Diaphragm
Spring
Full Rod
Rocker Arm

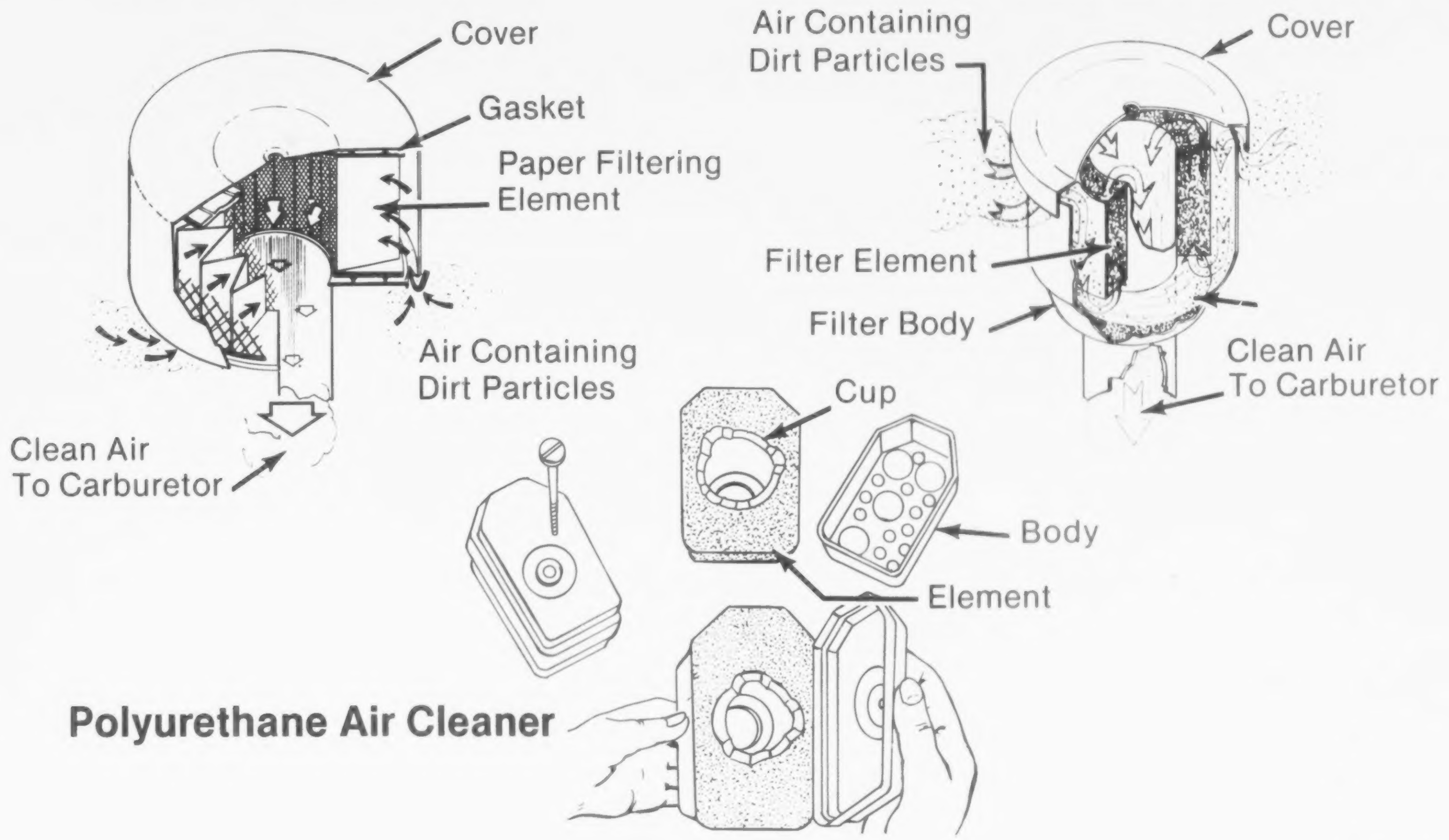
Cutaway View of Electric Fuel Pump


Filter Bowl
Filter Element
Valve Outlet
Fuel Out
Inlet Valve
Bellows
Armature
Electromagnet
Return Spring

Types of Air Cleaners

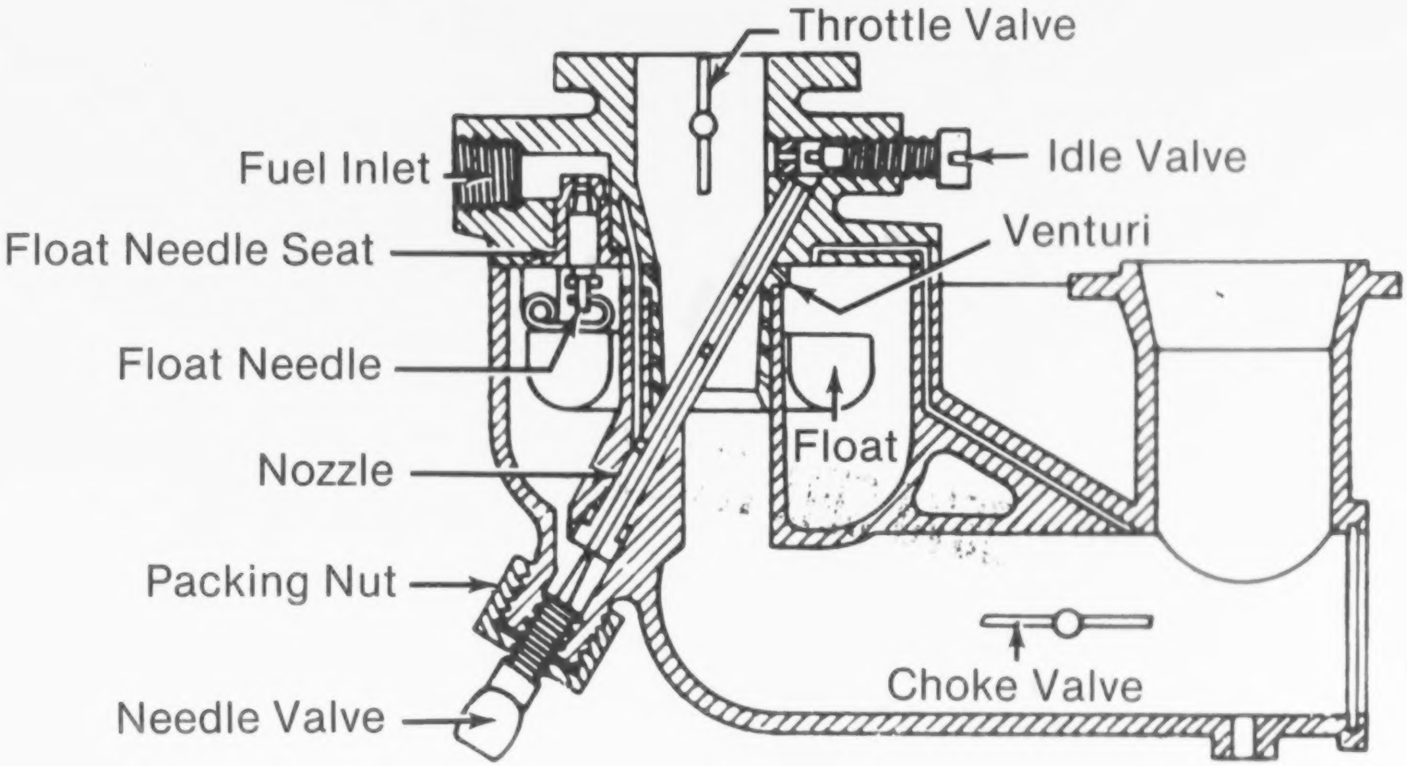
Dry-Filter Air Cleaner

Oil-Bath Air Cleaner

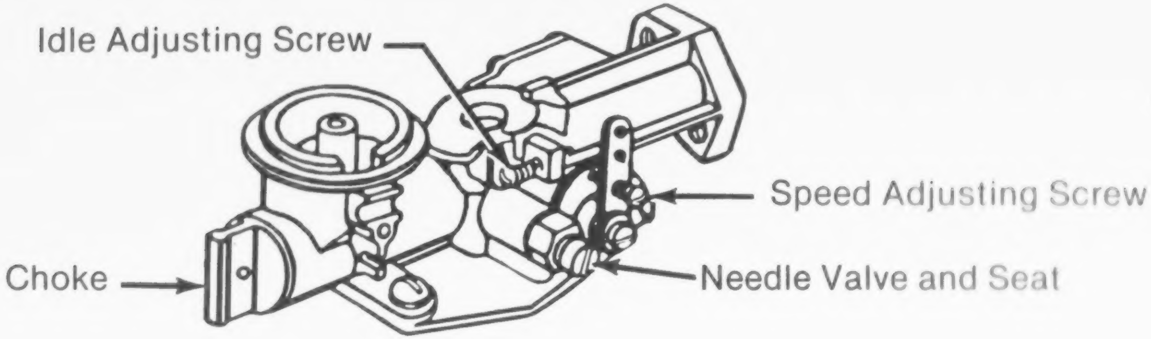

Cover
Gasket
Paper Filtering Element
Air Containing Dirt Particles
Clean Air To Carburetor
Air Containing Dirt Particles
Cover
Filter Element
Filter Body
Clean Air To Carburetor
Cup
Body
Element

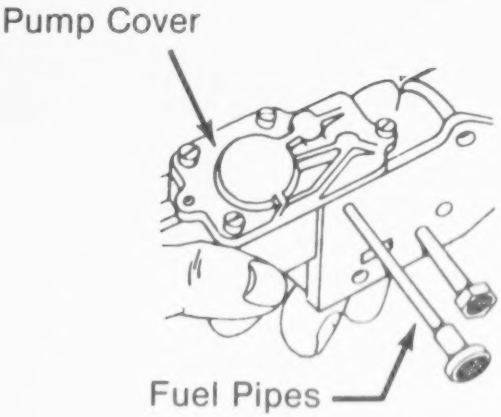
Polyurethane Air Cleaner

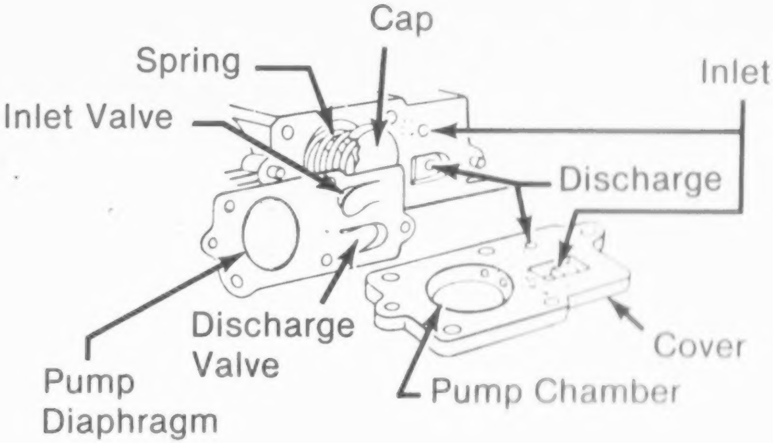
Parts of a Float Carburetor


Throttle Valve
Fuel Inlet
Idle Valve
Float Needle Seat
Venturi
Float Needle
Float
Nozzle
Packing Nut
Choke Valve
Needle Valve

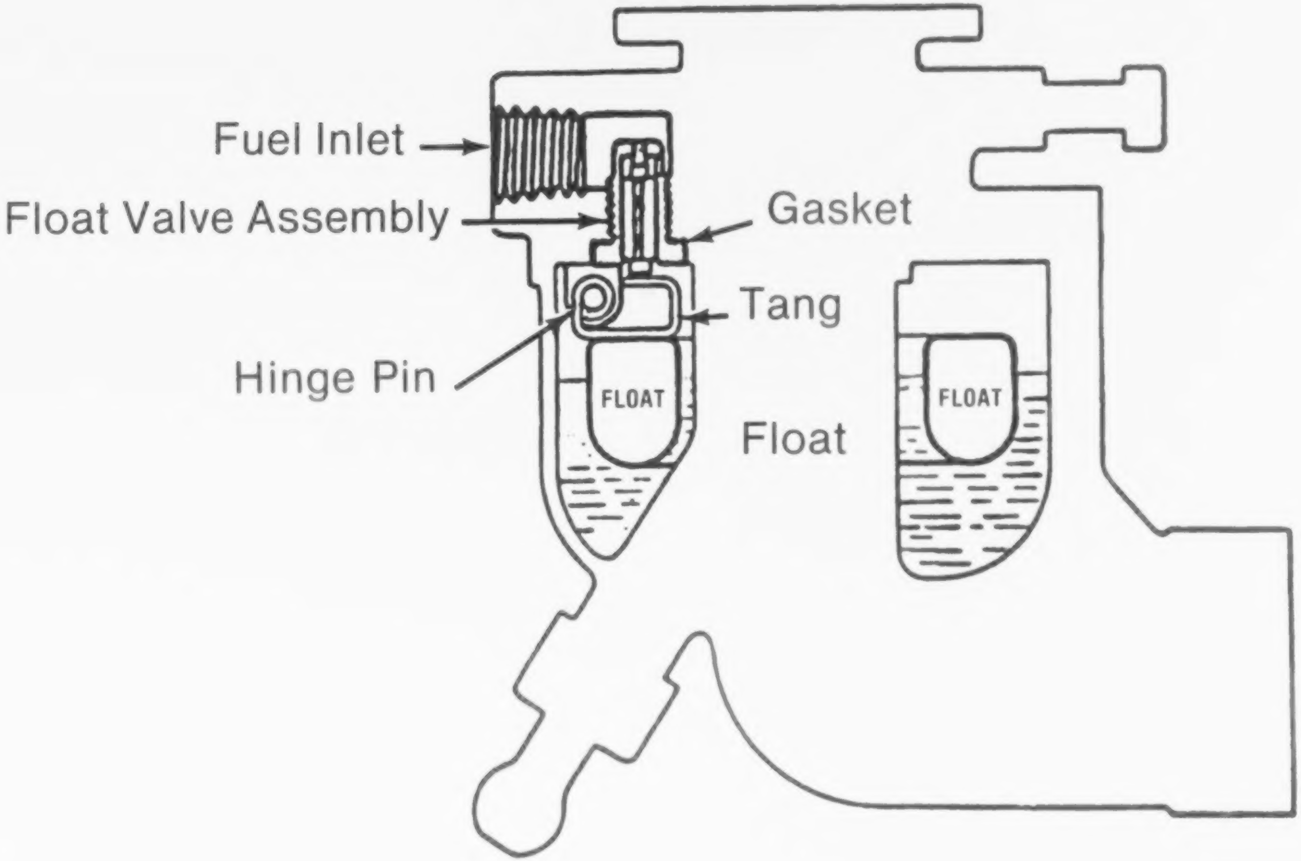
Parts of a Diaphragm Carburetor


Idle Adjusting Screw
Speed Adjusting Screw
Choke
Needle Valve and Seat

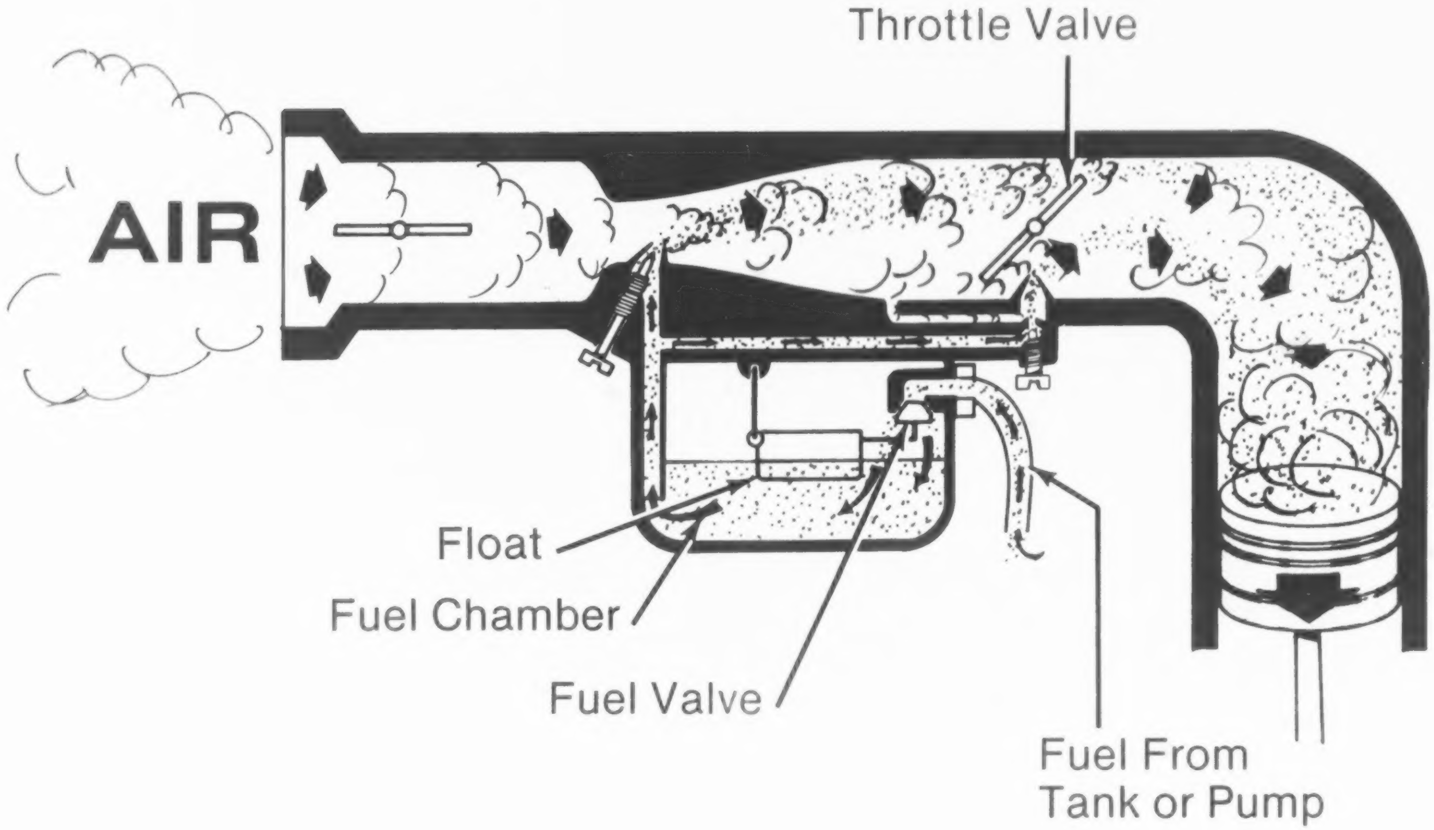

Pump Cover
Fuel Pipes


Cap
Spring
Inlet
Inlet Valve
Discharge
Discharge Valve
Cover
Pump Diaphragm
Pump Chamber

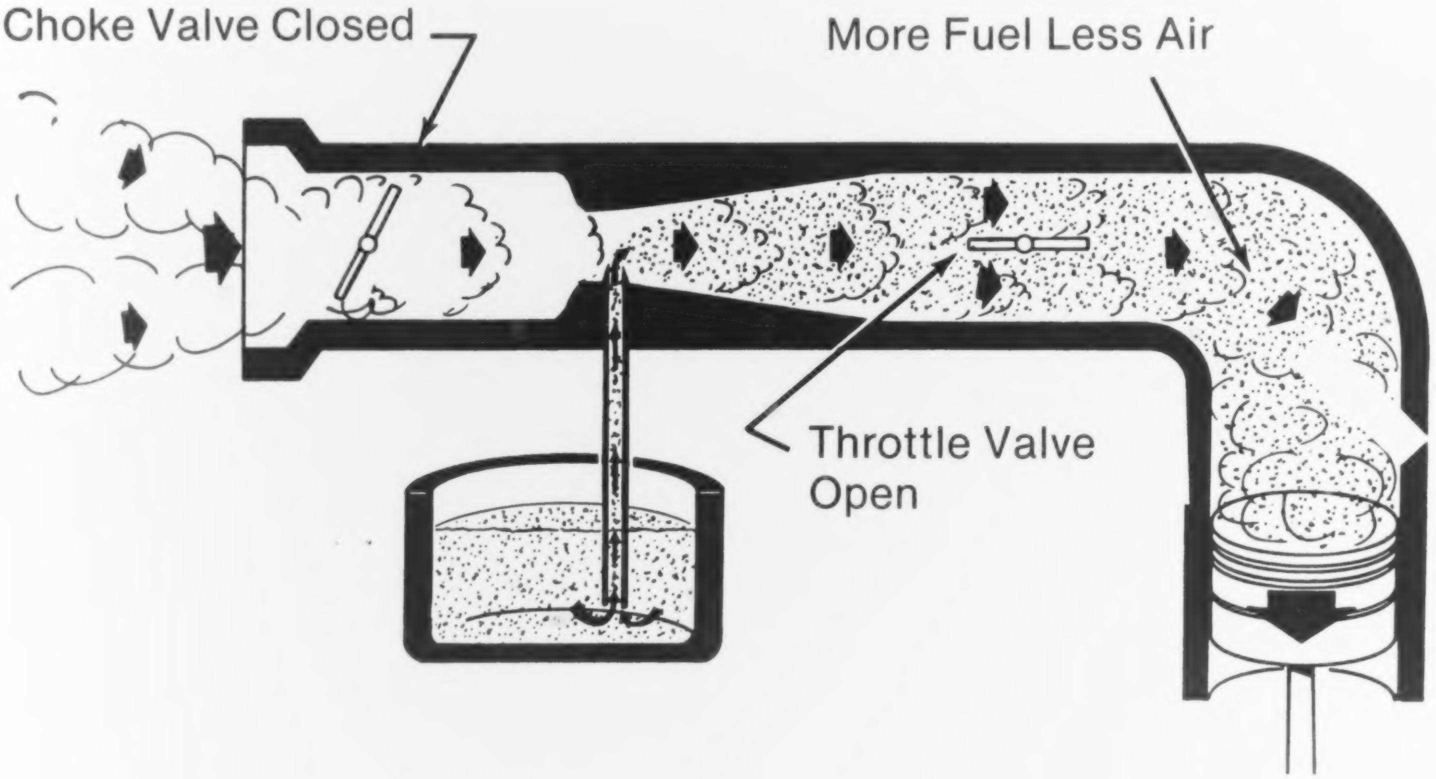
The Float System


Fuel Inlet
Float Valve Assembly
Gasket
Tang
Hinge Pin
FLOAT
Float
FLOAT

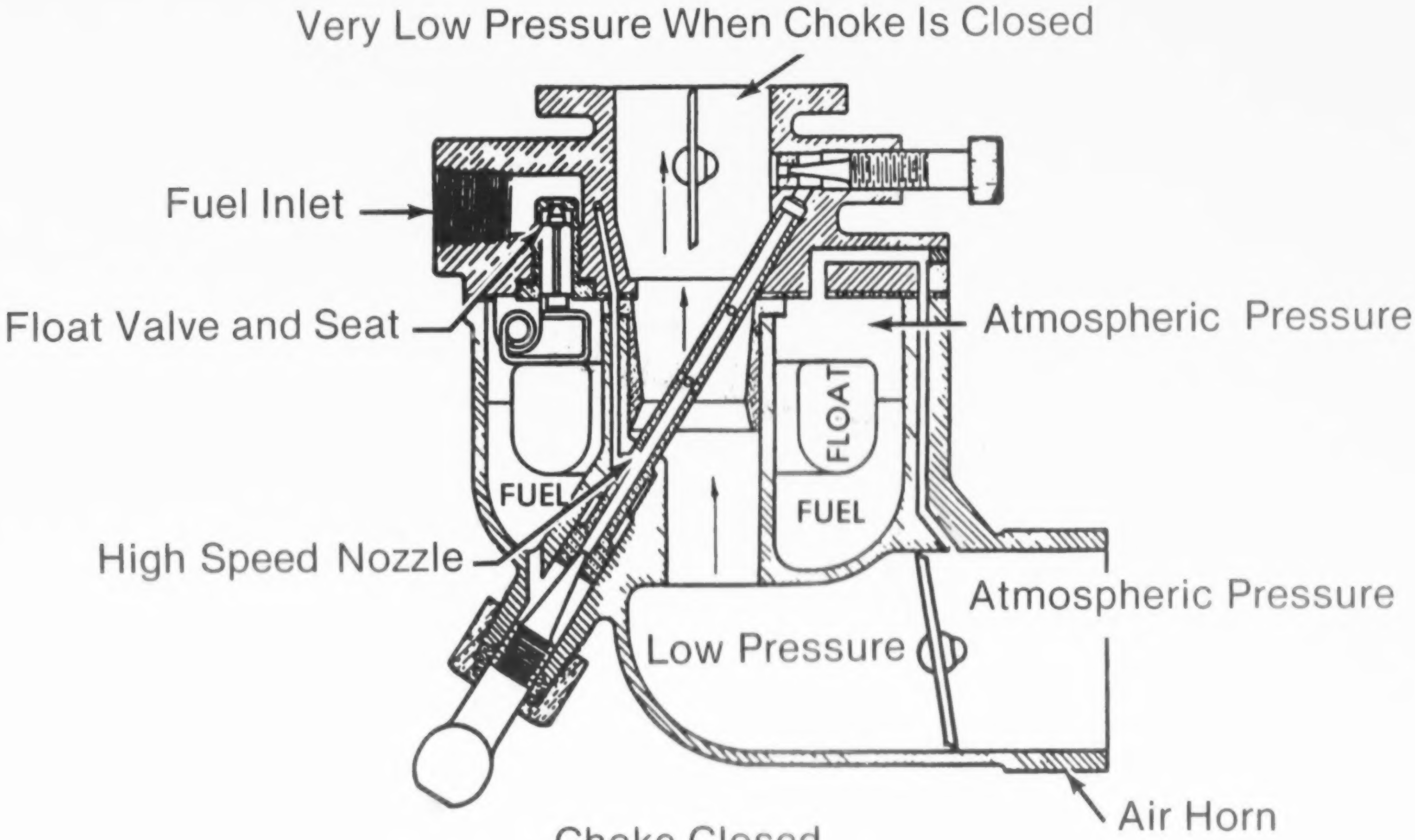
Float-Type Carburetor


Throttle Valve
AIR
Float
Fuel Chamber
Fuel Valve
Fuel From
Tank or Pump

Carburetor Choke Valve

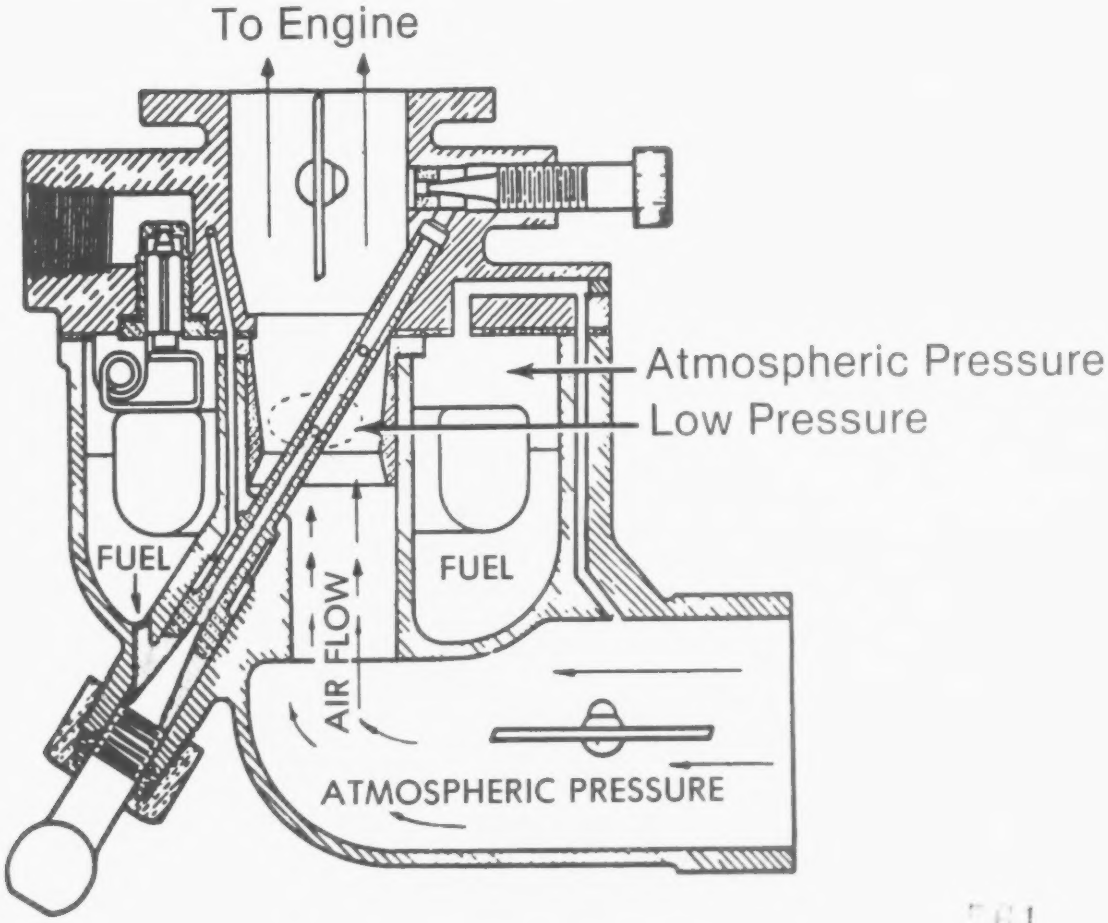

Choke Valve Closed
More Fuel Less Air
Throttle Valve Open

The Choke System

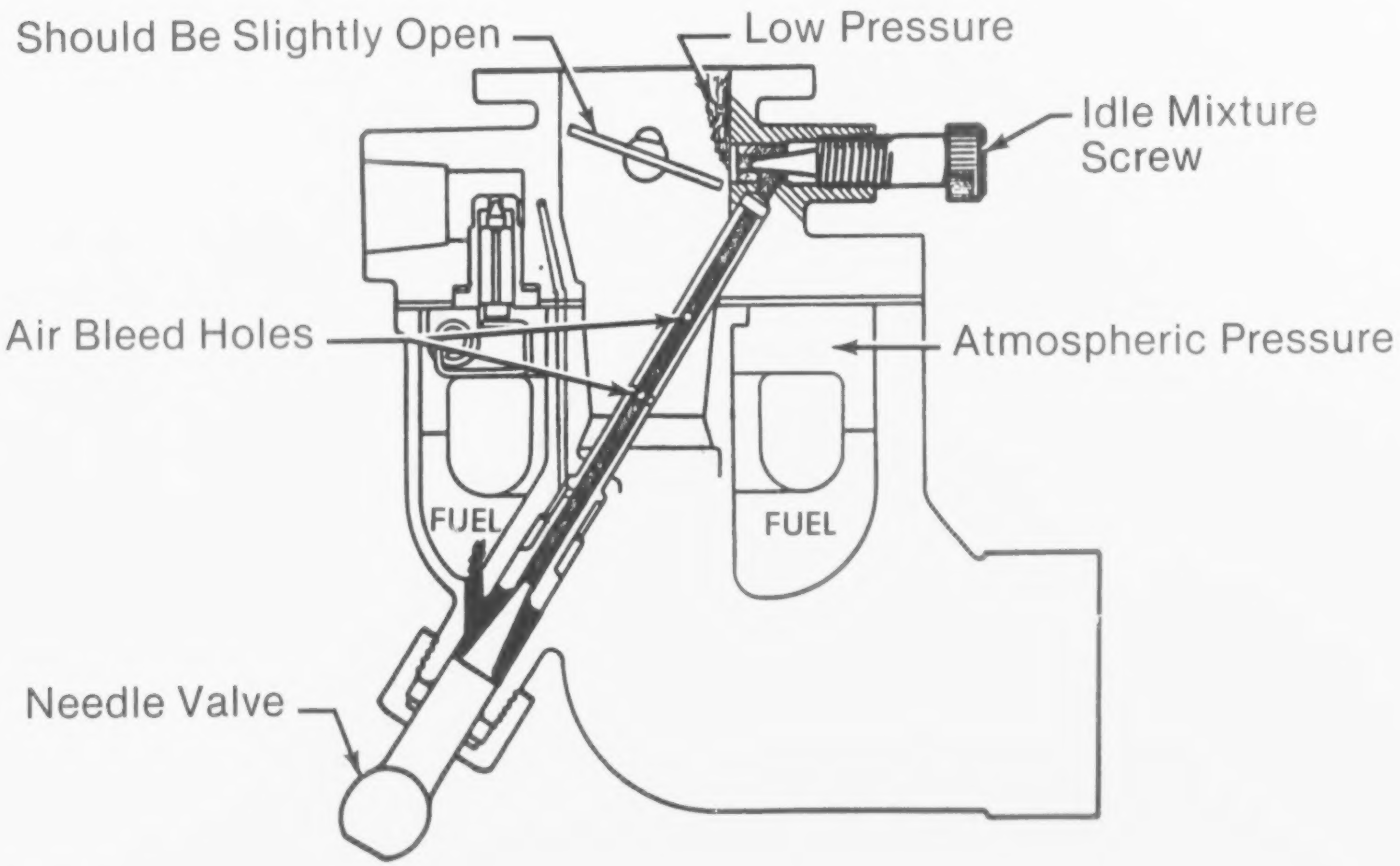

Very Low Pressure When Choke Is Closed
Fuel Inlet
Float Valve and Seat
Atmospheric Pressure
FLOAT
FUEL
FUEL
High Speed Nozzle
Atmospheric Pressure
Low Pressure
Air Horn

Choke Closed

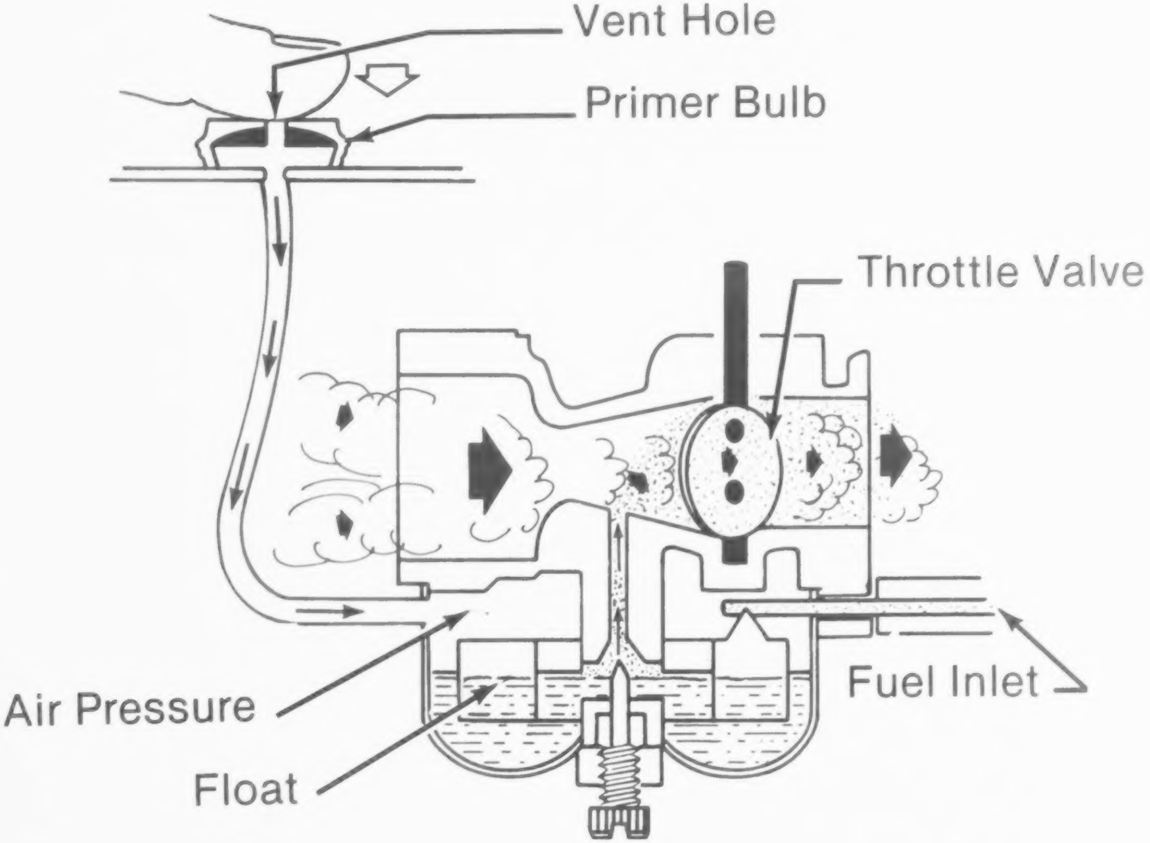
The High Speed System


To Engine
Atmospheric Pressure
Low Pressure
FUEL
FUEL
AIR FLOW
ATMOSPHERIC PRESSURE

The Idle System


Should Be Slightly Open
Low Pressure
Idle Mixture Screw
Air Bleed Holes
Atmospheric Pressure
FUEL
FUEL
Needle Valve

Bulb-Type Primer


Vent Hole
Primer Bulb
Throttle Valve
Fuel Inlet
Air Pressure
Float

FUEL SYSTEMS
UNIT IV-D

JOB SHEET #1 — SERVICE AN AIR CLEANER

A. Tools and materials needed

1. Compressed air
2. Container of solvent and cleaning brush
3. Shop towels
4. Screwdriver
5. Clean engine oil
6. Safety glasses

B. Procedure

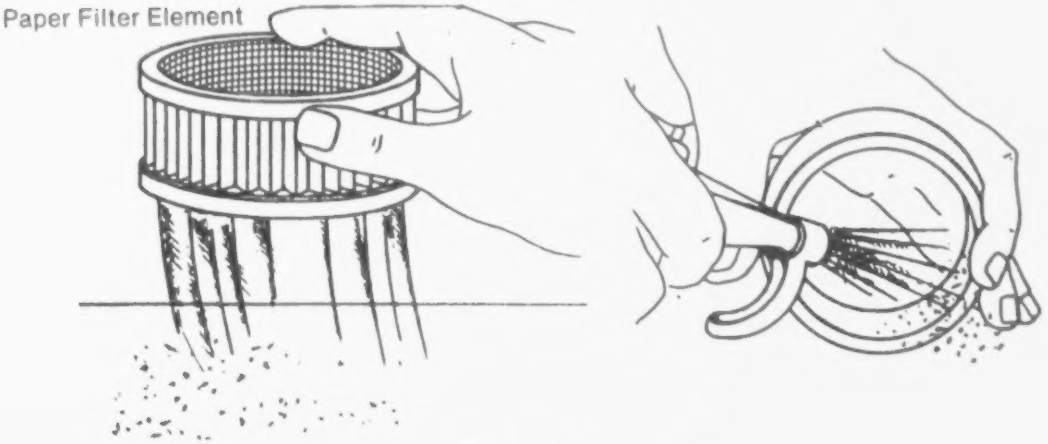
1. Disconnect and ground spark plug wire
2. Remove air cleaner fasteners
3. Remove air cleaner and air cleaner cover
4. Determine the type of air cleaner element
5. Service air cleaner according to type

   a. Service paper air cleaner element

   (NOTE: Paper air cleaner elements should be replaced at specified intervals.)

   1) Clean by tapping lightly on a flat surface or by directing a controlled stream of compressed air through the element opposite normal air flow (Figure 1)

FIGURE 1



JOB SHEET #1

2) Before reinstalling, check the element against the light to make sure there are no holes or ruptures present

(NOTE: Light should be visible. If not, discard element.)

3) Check bottom and top gasket surfaces of the paper element for damage

4) Install right side up when indicated

b. Service polyurethane element

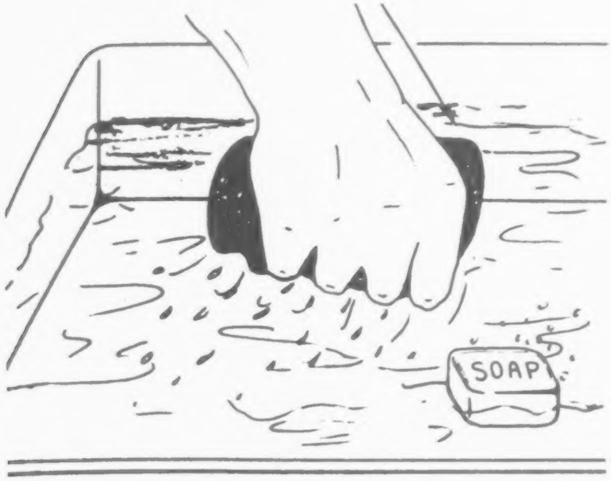
1) Remove the polyurethane element from the support screen

2) Wash it thoroughly (Figure 2)

(NOTE: the element can be washed in solvent or soap and water.)

(CAUTION: Never use gasoline to clean element.)

FIGURE 2



3) Squeeze out the solvent or soap and water

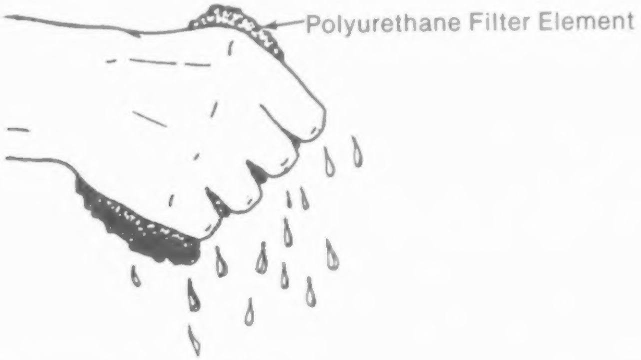
(NOTE: Do not wring, as the element might tear.)

4) Reoil the filter element with clean engine oil

JOB SHEET #1

5) Squeeze the excess oil from the filter element (Figure 3)

FIGURE 3


Polyurethane Filter Element

6) Replace element on support screen

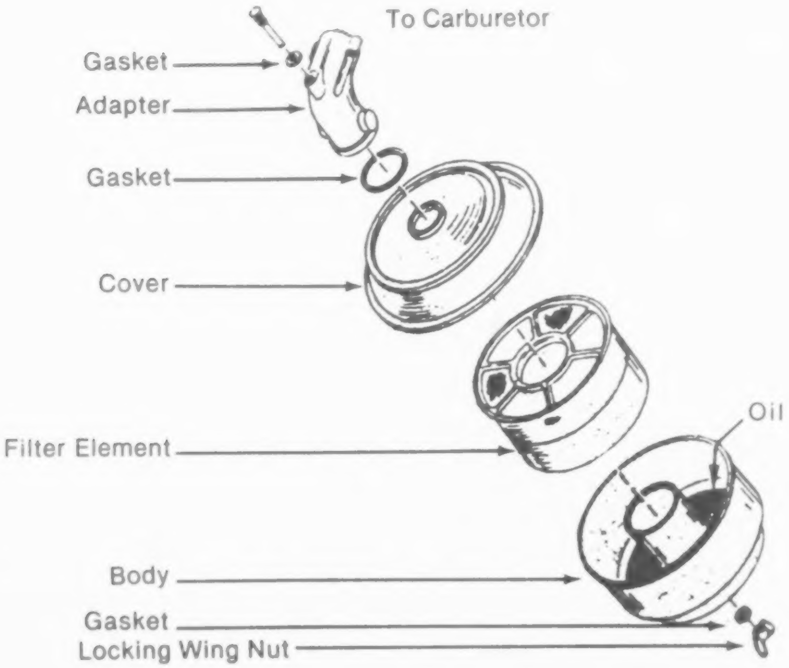
(NOTE: Make sure the element is placed on the support screen to form a sound seal for both top and bottom contact edges.)

c. Service oil bath air cleaner

1) Remove wing nut and separate parts for cleaning (Figure 4)

(NOTE: Dispose of old oil properly.)

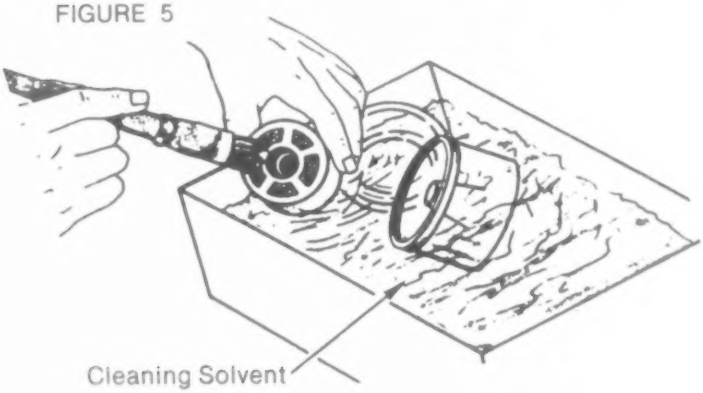
FIGURE 4


To Carburetor
Gasket
Adapter
Gasket
Cover
Filter Element
Oil
Body
Gasket
Locking Wing Nut

JOB SHEET #1

2) Rinse air strainer and parts in clean solvent (Figure 5)

FIGURE 5



3) Shake excessive solvent out of the air strainer

(CAUTION: Wear eye protection, as the solvent is harmful to the eyes.)

4) Saturate the air strainer gauze with light oil and allow excess to drip off

5) Wash dirt and grit out of lower cup with clean solvent

6) Fill lower cup to correct level with fresh engine oil of correct type for engine

7) Place units together and install wing nut

(NOTE: Make sure gasket is in place between the air strainer and lower cup.)

8) Tighten wing nut securely

6. Clean the filter body and cover before replacing

7. Make certain the air cleaner to carburetor gasket is in good condition and in place; replace if necessary

8. Replace the air cleaner body

   (NOTE: Make sure the air cleaner faces in the correct direction. If a locating tang or lug is present, make sure it engages properly.)

9. Tighten the air cleaner wing nut or bolt securely

   (NOTE: Avoid overtightening as this can cause carburetor warpage or improper operation of the choke.)

10. Install any hoses to air cleaner as required

FUEL SYSTEMS
UNIT IV-D

JOB SHEET #2 — REMOVE AND REPLACE A FLOAT-TYPE CARBURETOR

A. Tools and materials needed

1. Hand tool assortment
2. Tubing wrenches
3. Torque wrench
4. Safety glasses

B. Procedure

1. Disconnect and ground spark plug wire
2. Remove the air cleaner
3. Disconnect the fuel line

   (NOTE: Use a backup wrench to avoid twisting the fuel line. Use a container to catch gas drippings.)

4. Disconnect the throttle linkage
5. Disconnect the choke control cable if one is used
6. Remove the ignition ground wire if one is used
7. Remove the nuts or bolts that hold the carburetor
8. Remove the carburetor

   (NOTE: Some throttle linkages can only be removed at this time; be careful not to bend them and identify their correct mounting location.)

9. Remove the old carburetor to manifold gasket
10. Clean the gasket mounting surface

    (NOTE: Plug the manifold opening to prevent foreign material from entering engine.)

11. Install the new manifold to carburetor gasket

JOB SHEET #2

12. Place the carburetor in the correct position and start fasteners

    (NOTE: Some carburetors need to have the throttle linkage connected at this time; mount the linkage in correct locations.)

13. Tighten and torque carburetor fasteners

14. Replace throttle linkage if not connected before

15. Connect the choke linkage

16. Connect the ignition ground wire in the correct position

17. Connect the fuel line to the carburetor

    (NOTE: Use caution to avoid cross threading.)

18. Tighten the fuel line securely

    (NOTE: Use a backup wrench to avoid fuel line twisting.)

19. Check to make sure all connections and accessories are secure

20. Start the engine and check for leaks

    (CAUTION: A loose connection or unsecured fuel line can come loose, break, or leak. If this happens, fuel will leak and if ignited this fuel will cause a dangerous fire. Be correct in your work.)

21. Make idle air mixture and idle speed adjustments as required by engine manual

FUEL SYSTEMS
UNIT IV-D

JOB SHEET #3 — SERVICE A FLOAT-TYPE CARBURETOR

A. Tools and materials needed

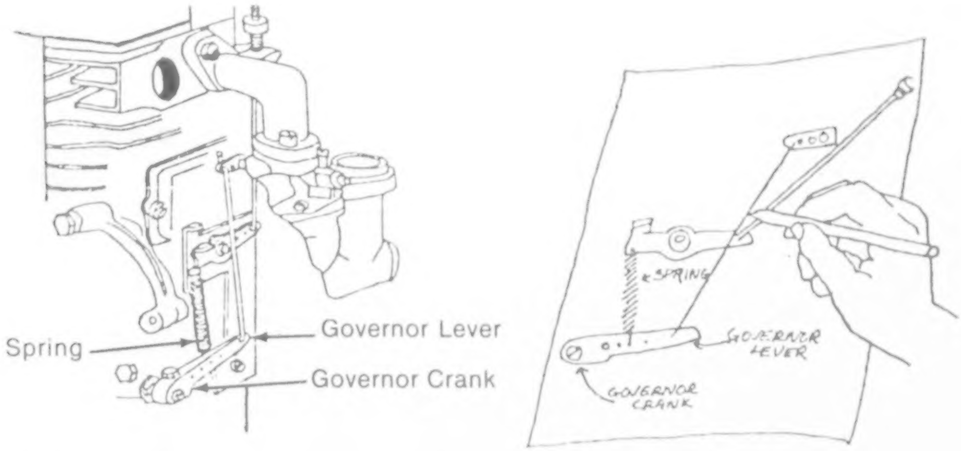
1. Hand tool assortment
2. Suitable carburetor cleaning fluid
3. Parts cleaning basket
4. Safety glasses

B. Procedure

1. Disconnect and ground spark plug wire
2. Close fuel shut-off valve
3. Disconnect fuel line
4. Disconnect throttle and choke cable
5. Disconnect governor linkage

(NOTE: It is recommended that you make a sketch of the linkages and their positions to aid reassembly. See Figure 1.)

FIGURE 1

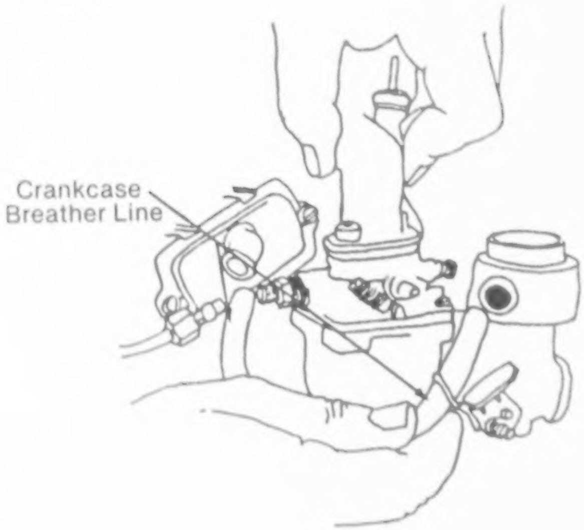

Spring
Governor Lever
Governor Crank
SPRING
GOVERNOR LEVER
GOVERNOR CRANK

JOB SHEET #3

6. Remove the carburetor

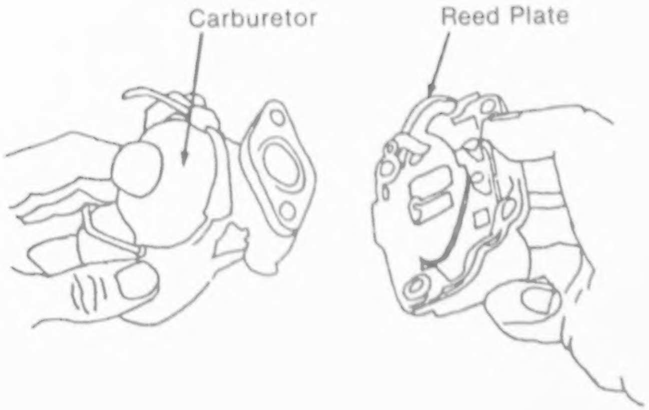
(NOTE: Some models have a breather return hose to disconnect. See Figure 2.)

FIGURE 2


Crankcase
Breather Line

7. Remove the intake valve plate from the carburetor on some two-cycle engines (Figure 3)

FIGURE 3

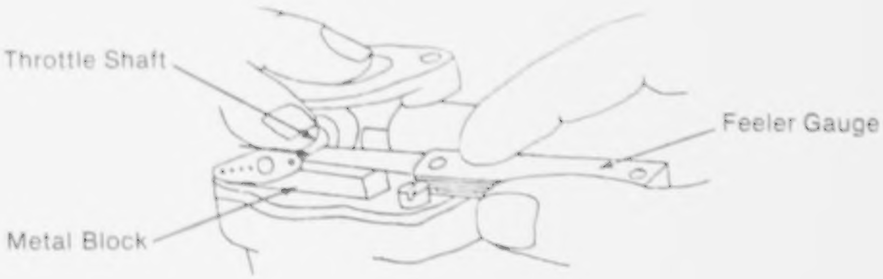

Carburetor
Reed Plate

JOB SHEET #3

8. Check throttle shaft bushing for wear (Figure 4)

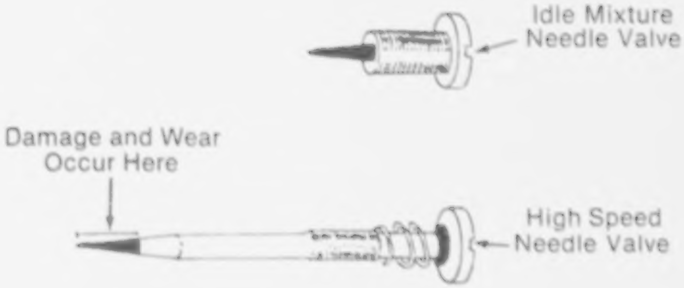
   (NOTE: Check engine manufacturer's specifications.)

   FIGURE 4


Throttle Shaft
Feeler Gauge
Metal Block

9. Remove and check the condition of the high speed and idle speed needle valves (Figure 5)

   FIGURE 5

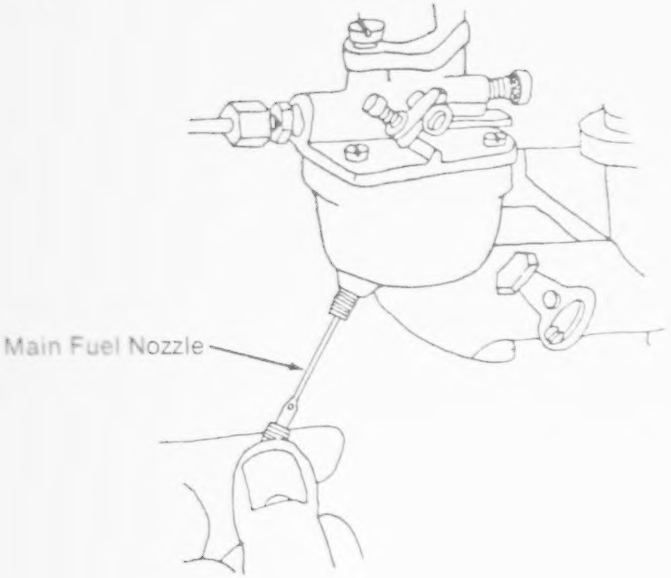

Idle Mixture Needle Valve
Damage and Wear Occur Here
High Speed Needle Valve

JOB SHEET #3

10. Remove the float bowl

(NOTE: On two piece carburetors remove the main fuel nozzle before removing float bowl. See Figure 6.)

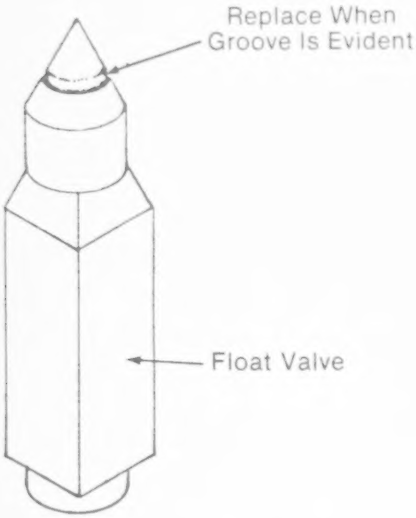
FIGURE 6


Main Fuel Nozzle

11. Remove float hinge pin and remove float

12. Remove float valve and inspect for wear; replace if a groove is worn in the tapered point of the valve (Figure 7)

FIGURE 7


Replace When
Groove Is Evident
Float Valve

JOB SHEET #3

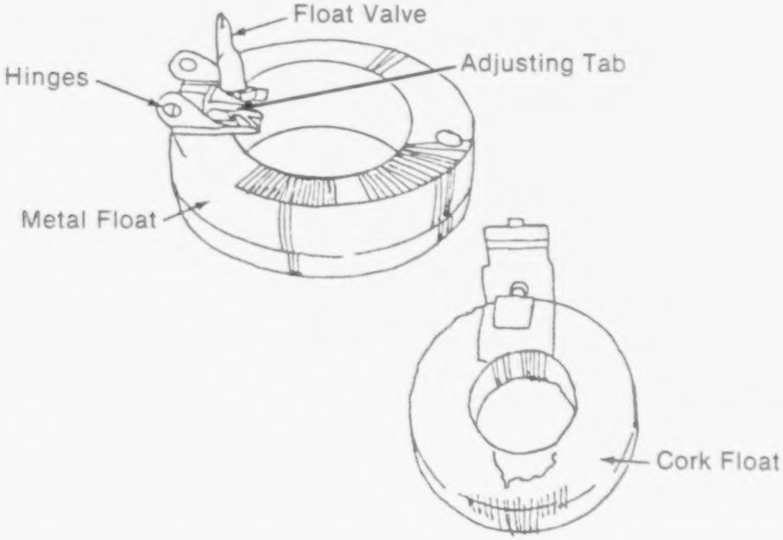
13. Inspect the floats for

    a. Worn hinges

    b. Fuel in metal floats; replace if you feel a liquid inside the float

    c. Good varnish coating on cork floats; replace the float if the varnish is peeling or has been punched (Figure 8)

FIGURE 8



14. Remove all gaskets and/or rubber parts on the carburetor

15. Place all the carburetor parts except the gaskets, float, and rubber parts in a cleaner basket

16. Place the basket in the carburetor cleaner and gently move it up and down to circulate the cleaner through the parts; then let it set for no more than thirty minutes

17. Remove the basket from the cleaner

18. Rinse the parts and basket thoroughly with water

19. Dry the parts, one at a time, with compressed air

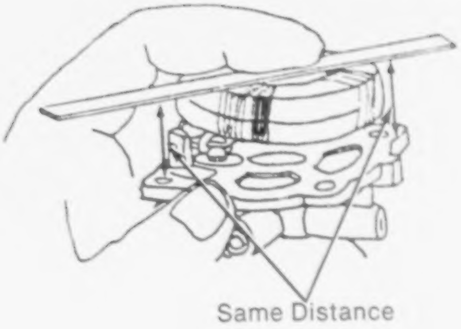
    (NOTE: Be sure to blow out all passage in the carburetor body.)

20. Replace float valve and float in the carburetor body

JOB SHEET #3

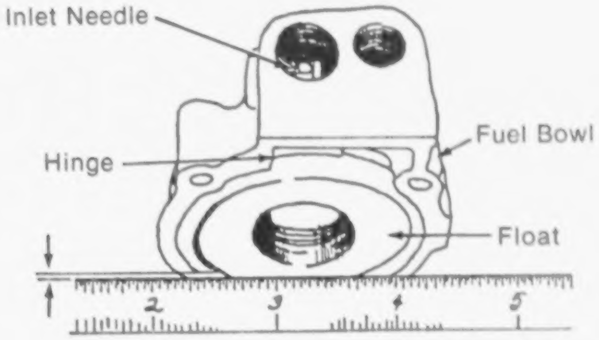
21. Adjust the float level by bending the tab and measuring correct height with a steel ruler (Figure 9)

FIGURE 9


Same Distance

22. Check distance from carburetor to float top for proper height and equal distance on horizontal float (Figure 10)

FIGURE 10

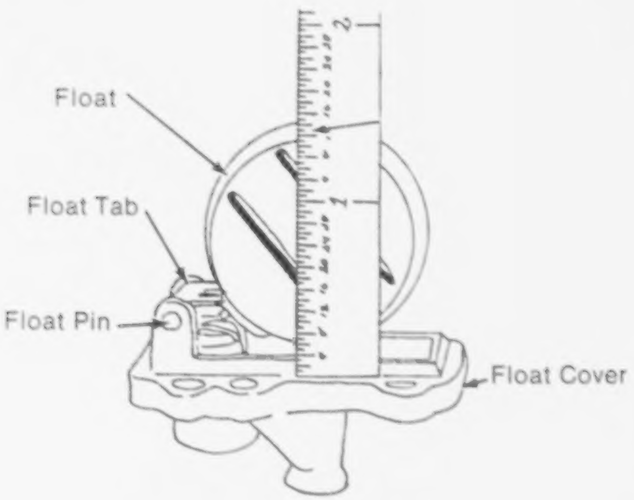

Inlet Needle
Fuel Bowl
Hinge
Float
2
3
4
5

JOB SHEET #3

23. Check distance on a vertical float from carburetor top to top of float

    (NOTE: Float should be true vertical to the carburetor top to prevent interference with float bowl walls. See Figure 11.)

FIGURE 11



24. Check bottom of float for proper clearance in relation to float bowl
25. Install new float bowl gasket and attach bowl to carburetor top
26. Install idle mixture valve and screw it down until it is lightly seated; then back it out approximately two turns

    (NOTE: Install the main fuel nozzle on the two-piece carburetor.)

27. Install the high speed valve and screw it down until it is lightly seated; then back it out approximately two turns

    (NOTE: Steps Y and Z are preliminary adjustments only and will be completed with the engine running.)

28. Check for free operation of the throttle and choke valve
29. Install the carburetor on the engine
30. Reconnect the governor linkage according to the diagram sketched earlier
31. Reconnect throttle and choke linkage

JOB SHEET #3

32. Reconnect fuel line

33. Open fuel shut-off valve and watch float bowl area of the carburetor for fuel leaks

    (NOTE: Occasionally the float valve will get contamination in it that will keep it from shutting off. In this case, a few *light* taps on the valve area may release the contamination and solve the problem.)

34. Start the engine and operate until it is at normal operating temperature

35. Adjust idle speed

36. Adjust the idle mixture valve to the highest and smoothest rpm at idle speed

    (NOTE: It may be necessary to reset the idle speed again.)

37. Accelerate the engine up to governor controlled rpm and adjust high speed valve to highest and smoothest rpm

FUEL SYSTEMS
UNIT IV-D

JOB SHEET #4 — REMOVE, SERVICE, AND REPLACE A DIAPHRAGM CARBURETOR

(NOTE: Illustrations for this job sheet courtesy of Briggs and Stratton Corporation.)

A. Tools and materials needed

1. Hand tool assortment
2. Special carburetor screwdrivers
3. Carburetor cleaning fluid
4. Parts cleaning basket
5. Carburetor repair kit
6. Diaphragm
7. Shop towels
8. Safety glasses

B. Procedure

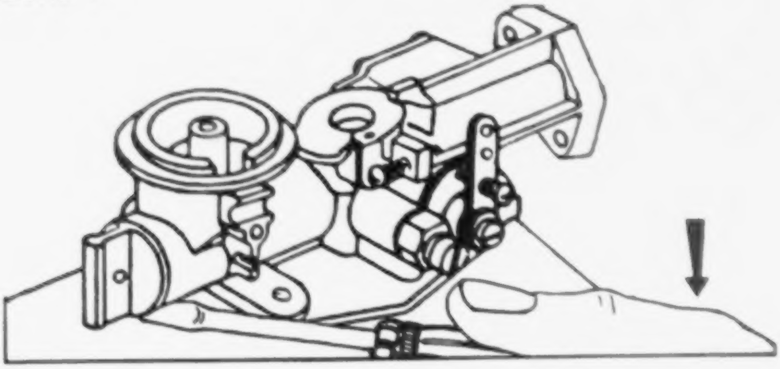
1. Read operator's manual
2. Organize your work station
3. Wear proper safety equipment
4. Disconnect and ground spark plug wire
5. Remove air cleaner
6. Inspect carburetor and fuel tank for leakage
7. Remove remote control
8. Remove the carburetor and tank assembly

JOB SHEET #4

9. Remove screws from carburetor (Figure 1)

(NOTE: Use a screwdriver to loosen carburetor from tank. See Figure 1.)

FIGURE 1

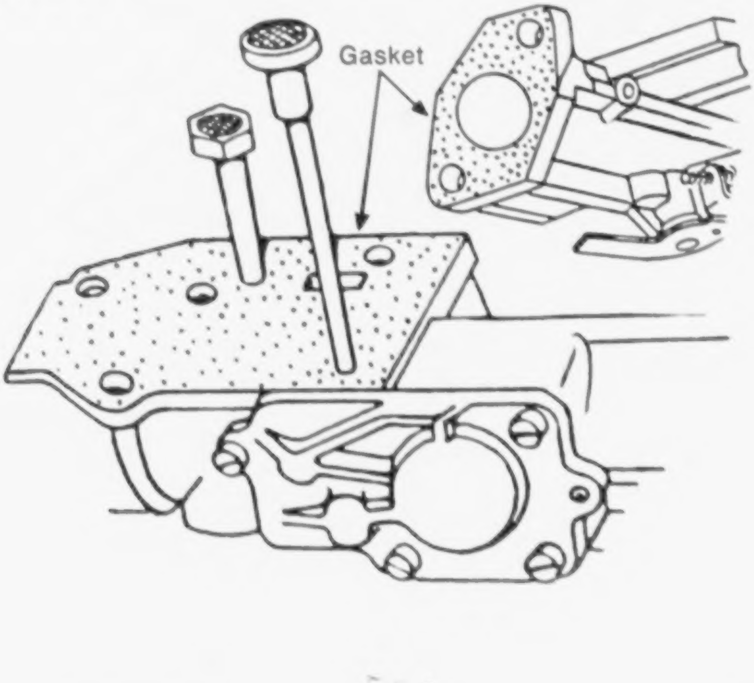


10. Slowly remove carburetor from fuel tank

11. Inspect gasket surface of carburetor (Figure 2)

(NOTE: Always replace with new gasket.)

FIGURE 2



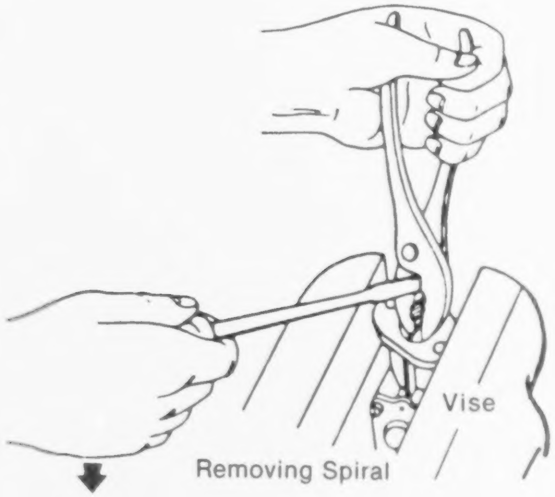
JOB SHEET #4

12. Replace worn throttle if needed

(NOTE: Do not remove throttle if it does not need to be replaced.)

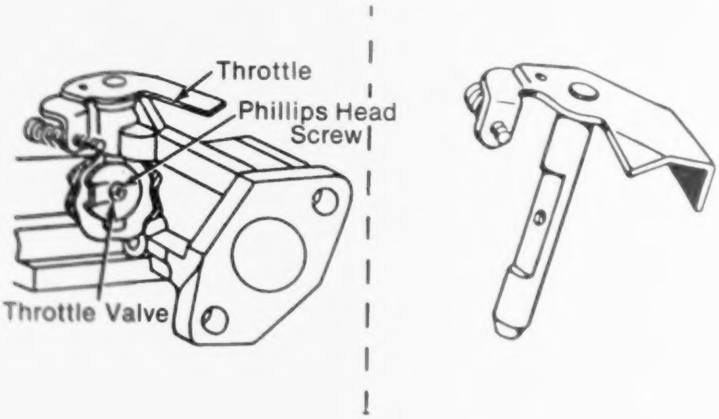
a. Remove spiral (Figure 3)

FIGURE 3


Vise
Removing Spiral

b. Use a phillips screwdriver to remove the throttle valve and screw (Figure 4)

FIGURE 4

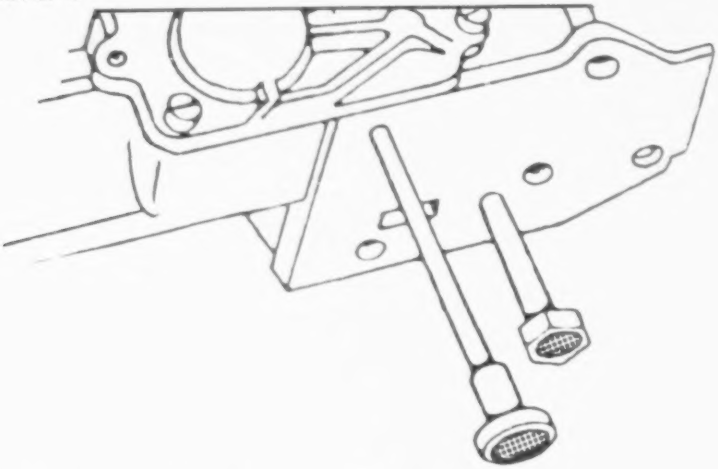

Throttle
Phillips Head Screw
Throttle Valve

JOB SHEET #4

13. Inspect the screens for gum deposits and dirt without removing the fuel pipes from carburetor body (Figure 5)

    (NOTE: Remove pipes only if they are being replaced.)

FIGURE 5



14. Clean the screens with a solvent and air dry

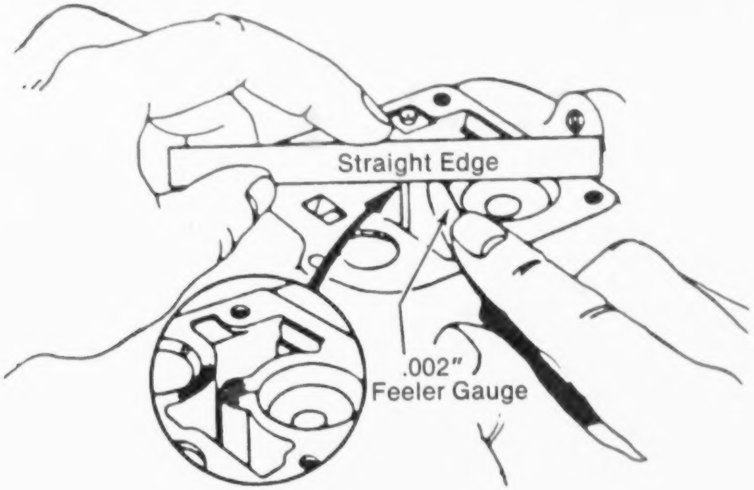
15. If fuel pipes must be replaced, use a socket wrench to loosen and remove

    (NOTE: When removing the fuel pipes, support pipe shaft near the carburetor body to prevent breakage. When inserting new pipes do not over-torque.)

16. Inspect top surface of fuel tank for flatness (Figure 6)

    (NOTE: A .002" feeler gauge should not fit between the straight edge and machined surface. Tank should be replaced if gauge will fit.)

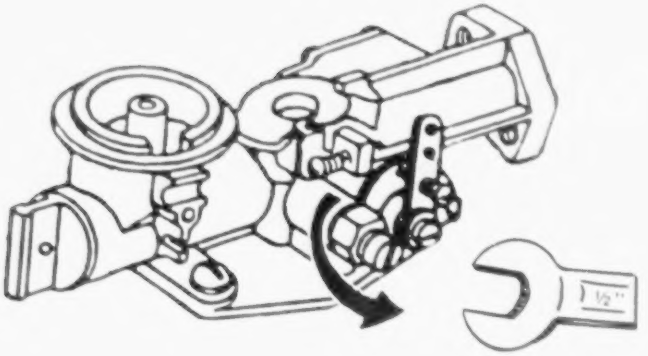
FIGURE 6



JOB SHEET #4

17. Loosen nut to remove needle valve and inspect needle for damage (Figure 7)

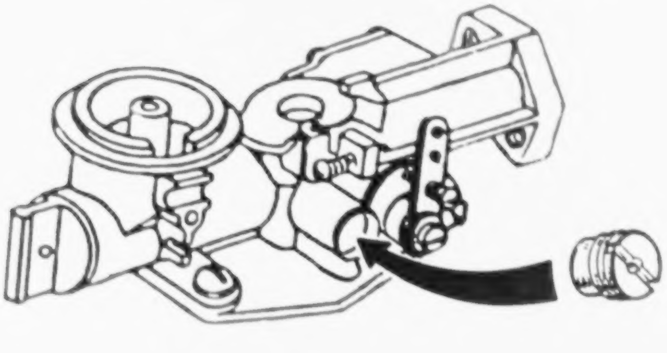
FIGURE 7



18. Remove brass seat and inspect for damage (Figure 8)

FIGURE 8

(NOTE: The needle valve kit includes both the needle and the seat. If either is damaged, both must be replaced.)

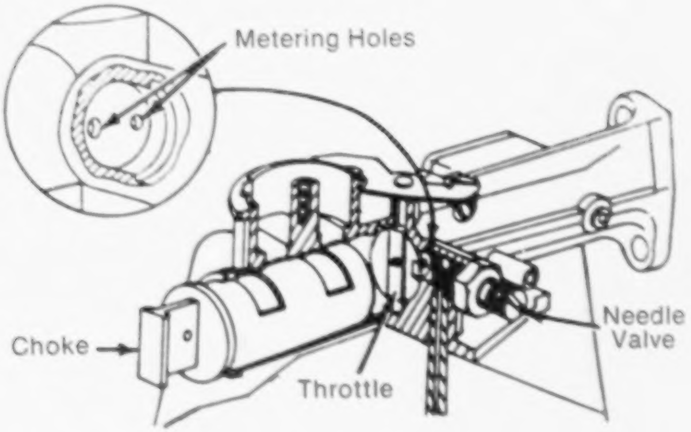


JOB SHEET #4

19. Inspect metering holes and air passages in the carburetor for dirt or obstructions (Figure 9)

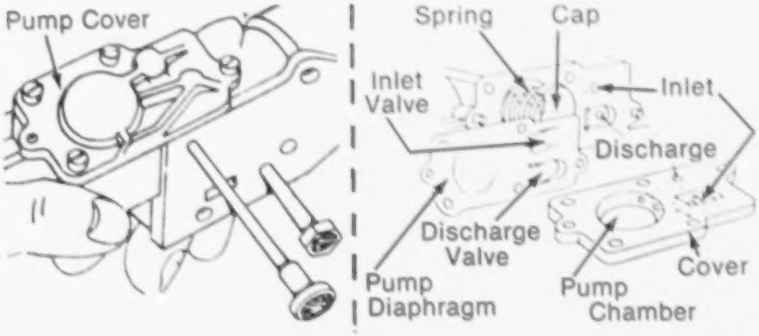
(NOTE: Use compressed air, not sharp objects, to clean out passages.)

FIGURE 9


Metering Holes
Choke
Throttle
Needle Valve

20. Remove screws from fuel pump cover and remove diaphragm, spring, and cap (Figure 10)

FIGURE 10


Pump Cover
Spring
Cap
Inlet Valve
Inlet
Discharge
Discharge Valve
Pump Diaphragm
Pump Chamber
Cover

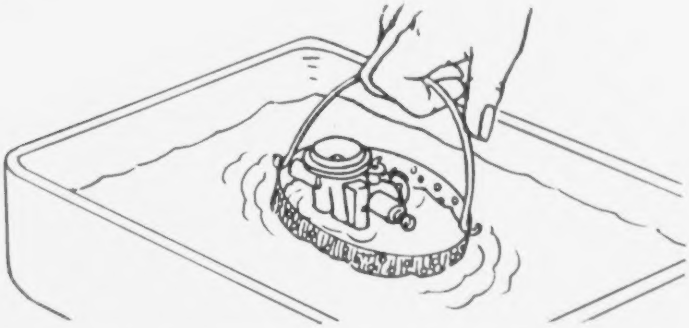
21. Inspect diaphragm for cracks and punctures

JOB SHEET #4

22. Clean gummy or dirty fuel tanks, lines, and carburetors in a carburetor cleaner (Figure 11)

    (NOTE: Do not soak diaphragm, gaskets, or nylon parts in the carburetor cleaner.)

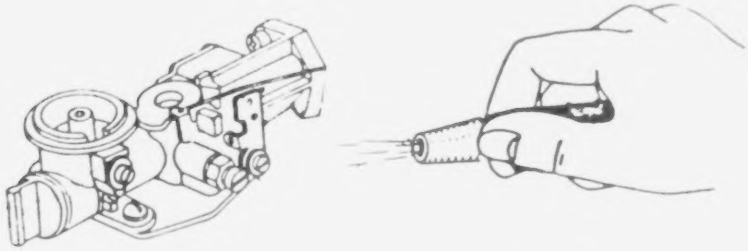
    FIGURE 11



23. Use compressed air to clean carburetor parts (Figure 12)

    (NOTE: Do not use a cloth rag, as lint could become trapped in carburetor parts.)

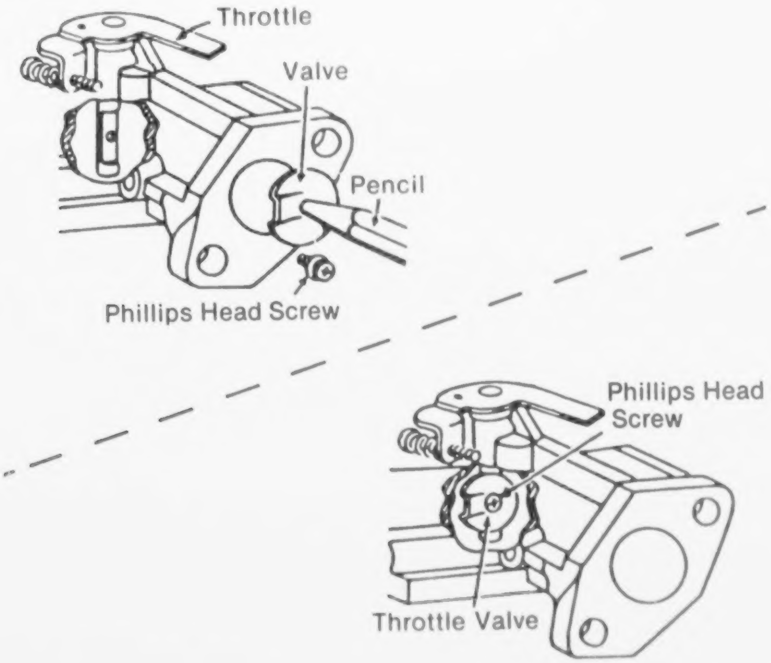
    FIGURE 12



JOB SHEET #4

24. Install throttle in carburetor; guide the throttle valve in place and tighten screw securely (Figure 13)

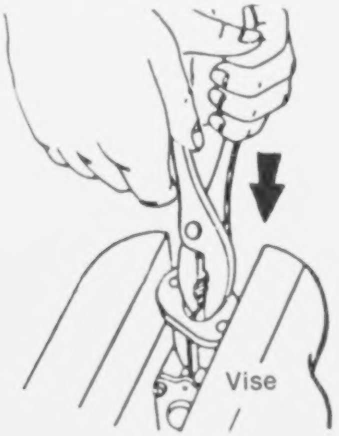
FIGURE 13


Throttle
Valve
Pencil
Phillips Head Screw
Phillips Head Screw
Throttle Valve

25. Install spiral in carburetor, use a vise to hold carburetor and slowly twist spiral in carburetor (Figure 14)

(NOTE: Top of spiral must be flush or 1/32" below carburetor flange.)

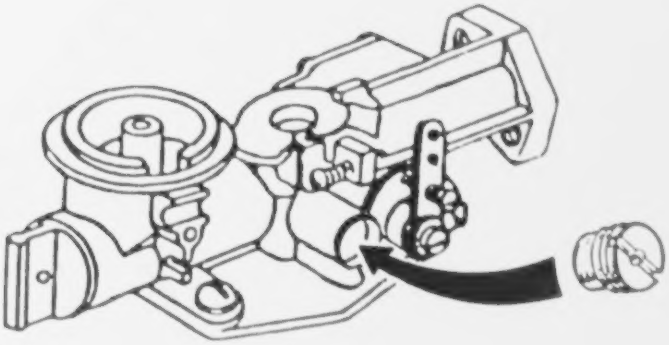
FIGURE 14



JOB SHEET #4

26. Install needle valve seat in carburetor and tighten securely (Figure 15)

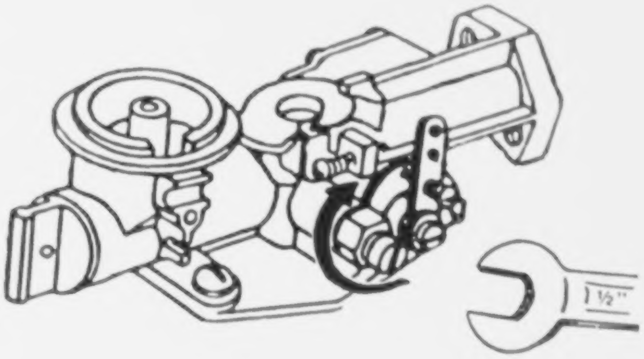
FIGURE 15



27. Insert needle valve into seat and tighten nut securely; turn the needle valve clockwise to close it, then open 1 ½ turns (Figure 16)

(NOTE: Before installing, screw the needle out until it is flush with the threads to prevent damage to the new needle and seat.)

FIGURE 16



JOB SHEET #4

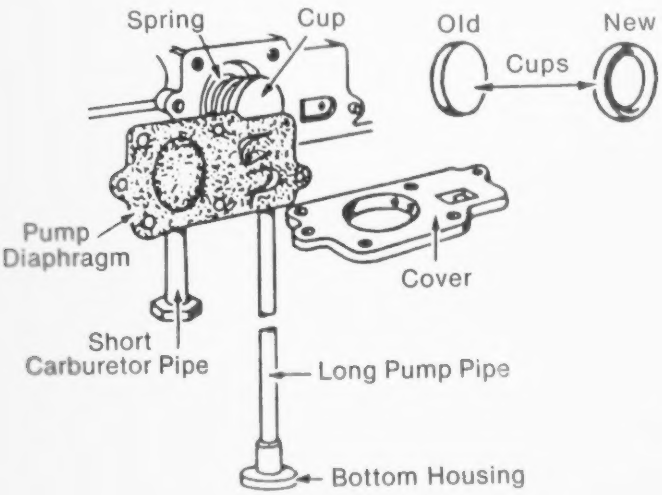
28. Reassemble pump, placing spring and cup in carburetor body

    a. Insert diaphragm and cover

    b. Tighten the screws in a staggered sequence to insure a good seal (Figure 17)

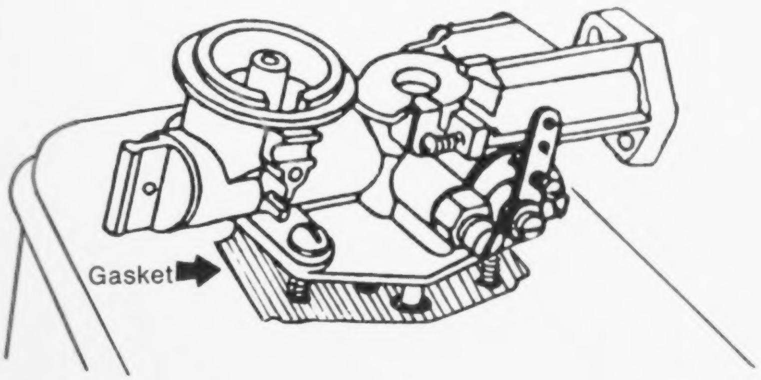
    (NOTE: Always install a new diaphragm when servicing carburetor.)

FIGURE 17


Spring
Cup
Old
New
Cups
Pump Diaphragm
Cover
Short Carburetor Pipe
Long Pump Pipe
Bottom Housing

29. Place gasket on fuel tank; install carburetor onto fuel tank and tighten screws securely (Figure 18)

FIGURE 18



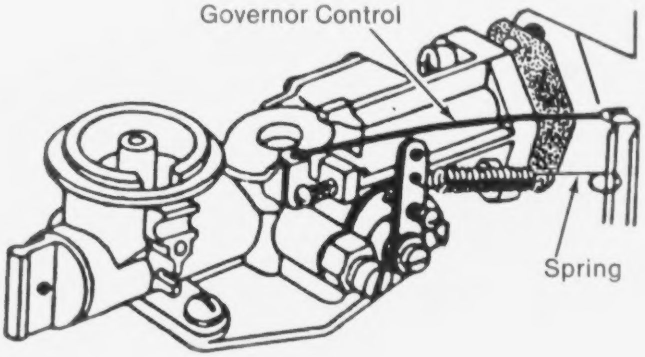
JOB SHEET #4

30. Place gasket on carburetor (Figure 19)

    a, While holding carburetor in place, hook up governor control and spring

    b. Thread screws into engine and tighten securely

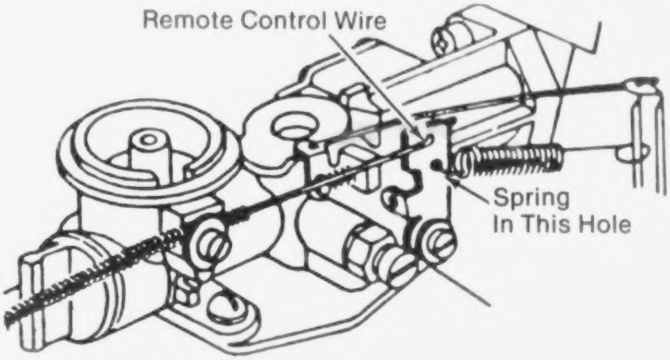
    FIGURE 19


Governor Control
Spring

31. On models equipped with a stop switch, install the ground wire

32. Install remote control assembly (Figure 20)

    FIGURE 20

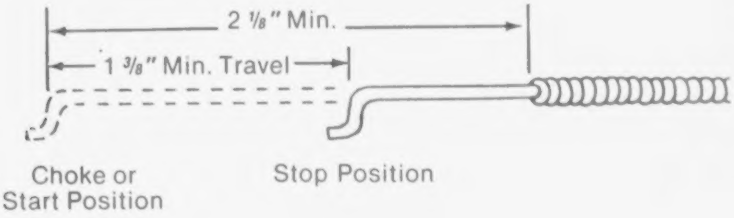

Remote Control Wire
Spring
In This Hole

JOB SHEET #4

33. Adjust remote control to "stop" position and tighten mounting screws (Figure 21)

    (NOTE: The control wire should have a minimum travel of 1 3/8".)

    FIGURE 21


2 1/8" Min.
1 3/8" Min. Travel
Choke or Start Position
Stop Position

34. Reconnect the spark plug wire

35. Install air cleaner

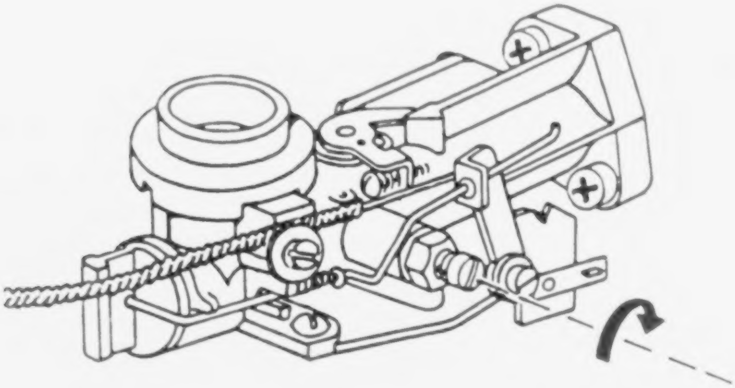
36. Start engine and warm up to operating temperature

    (NOTE: Tank should be completely full of gas.)

37. Place governor speed control in "fast" position and make the following adjustment to obtain the proper fuel mixture

    a. Turn needle valve in, clockwise, until engine begins to miss (lean mixture) (Figure 22)

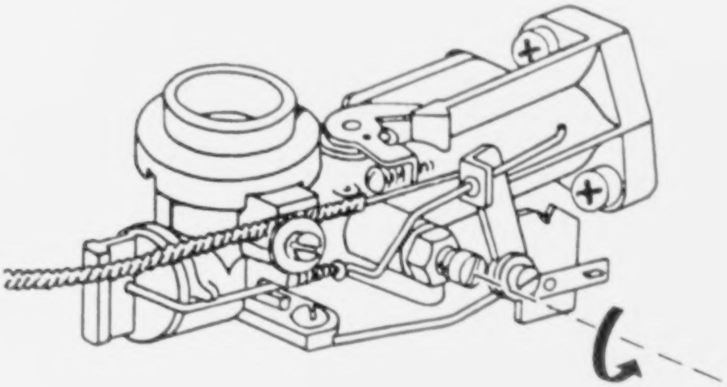
    FIGURE 22



JOB SHEET #4

b. Slowly turn needle valve out, counterclockwise, until engine runs unevenly (rich mixture) (Figure 23)

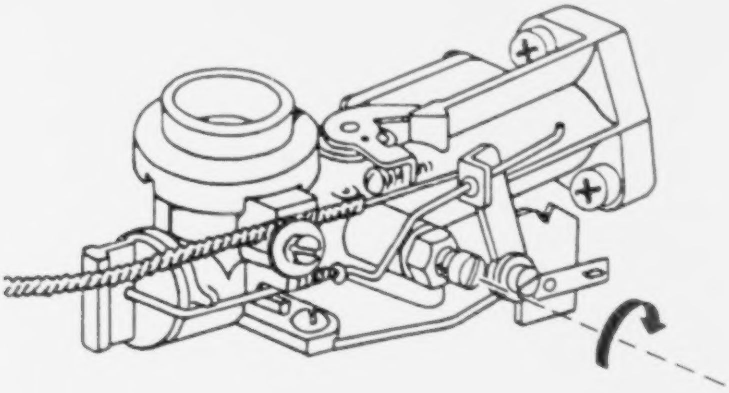
FIGURE 23



c. Turn needle clockwise to a smooth operating point between rich and lean mixture (Figure 24)

(NOTE: When engine does not accelerate properly, the carburetor should be readjusted to a slightly richer mixture.)

FIGURE 24



JOB SHEET #4

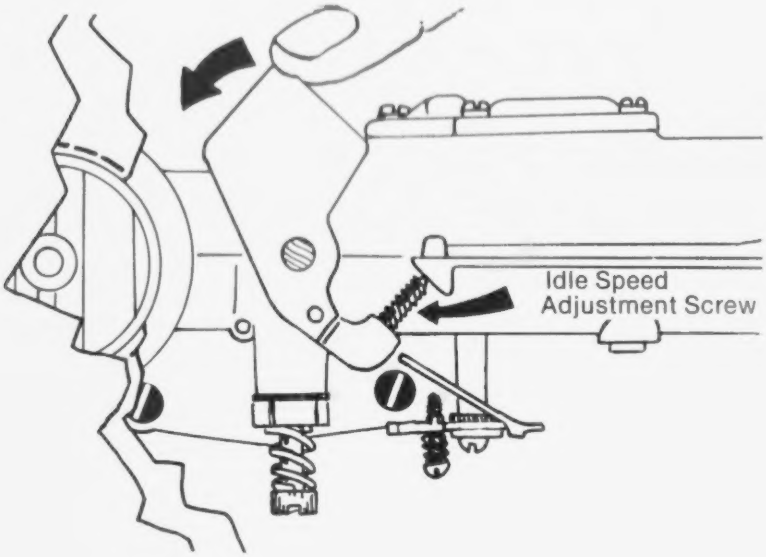
38. Adjust idle speed (Figure 25)

    a. Rotate throttle counterclockwise and hold against the stop

    b. Adjust idle speed adjustment screw to 1750 rpm

    (NOTE: The idle speed should be set with a tachometer.)

    FIGURE 25



39. Clean work area and return tools to their proper places.

FUEL SYSTEMS
UNIT IV-D

JOB SHEET #5 — REMOVE AND REPLACE A FUEL PUMP

A. Tools and materials needed

1. Hand tool assortment
2. Torque wrench
3. Shop towels
4. Gasket sealer
5. Safety glasses

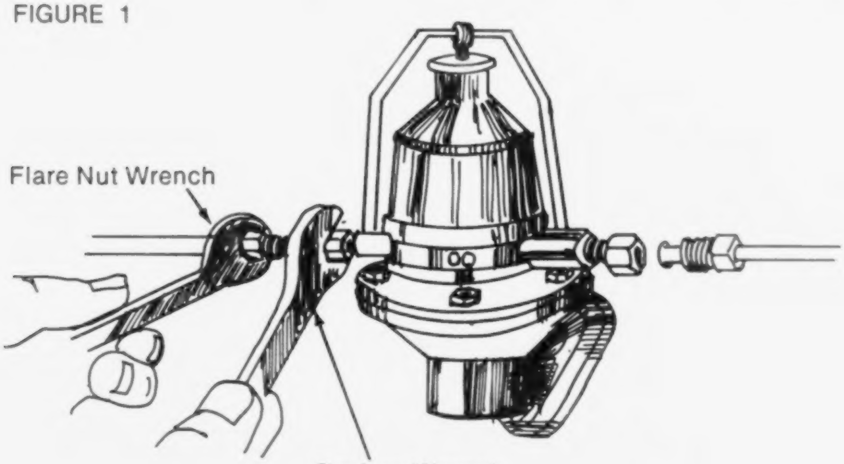
B. Procedure

1. Disconnect and ground spark plug wire
2. Shut off fuel at tank
3. Disconnect fuel lines from fuel pump

   (NOTE: Use a backup wrench and a tubing wrench if available to avoid twisting the line. See Figure 1.)

   (CAUTION: Do not allow fuel to drop as this will cause a danger of fire.)

FIGURE 1



JOB SHEET #5

4. Remove fuel pump

   (NOTE: Check location of fuel pump arm so it can be returned to same location.)

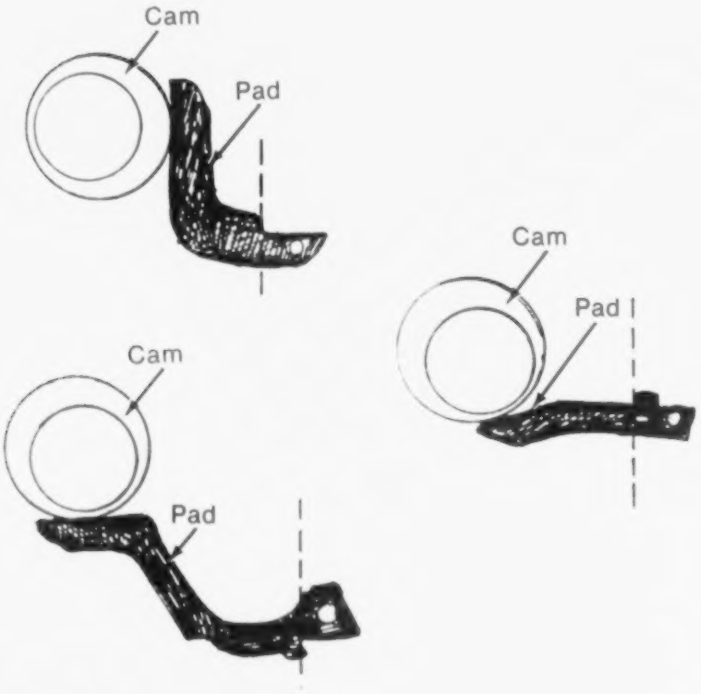
5. Clean fuel pump mounting surface on engine

6. Coat the mounting surfaces of the fuel pump and engine with gasket sealer

7. Install a new mounting gasket on the pump

8. Install pump with arm in same location as when pump was removed (Figure 2)

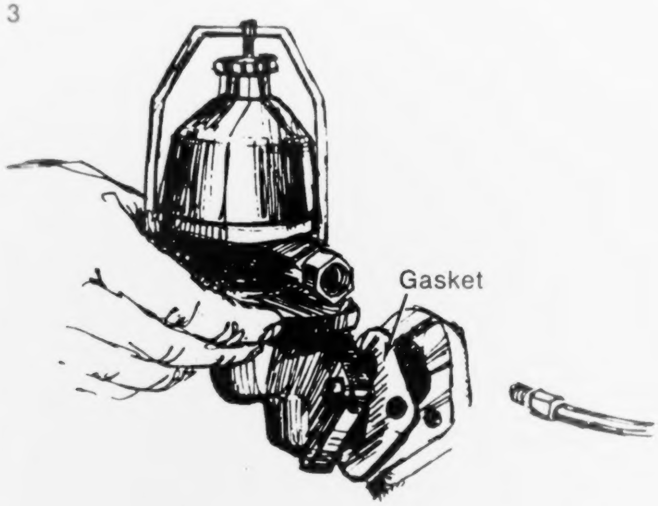
FIGURE 2



JOB SHEET #5

9. Push pump inward until the mounting flange is against the mounting pad (Figure 3)

FIGURE 3



10. Install fasteners and torque to specifications

    (NOTE: Do not force pump by using force of fasteners to pull it in.)

11. Attach the fuel lines

    (NOTE: Be sure threads are in alignment and finger start to prevent cross threading.)

12. Tighten fuel lines securely

    (NOTE: Use two wrenches to prevent damage to fuel lines and fittings.)

13. Turn on fuel at tank

14. Start engine and check for leaks; if a leak appears, stop engine immediately and repair

15. Clean up work area and return all tools

16. Have instructor inspect your work

FUEL SYSTEMS
UNIT IV-D

JOB SHEET #6 — TEST AND SERVICE A FUEL PUMP

A. Tools and materials needed

1. Hand tool assortment
2. Container to catch fuel in
3. Shop towels
4. Safety glasses

B. Procedure

1. Disconnect and ground spark plug wire
2. Disconnect fuel line at carburetor

   (NOTE: Use two tubing wrenches to prevent damaging fittings and fuel lines.)

3. Hold a small container under the fuel line to catch fuel
4. Crank the engine
5. Fuel should flow out strongly and in regular squirts

   (NOTE: If fuel flow is weak or erratic, check the fuel lines or fuel filter. If clear, the fuel pump should be replaced.)

6. Remove pump from engine

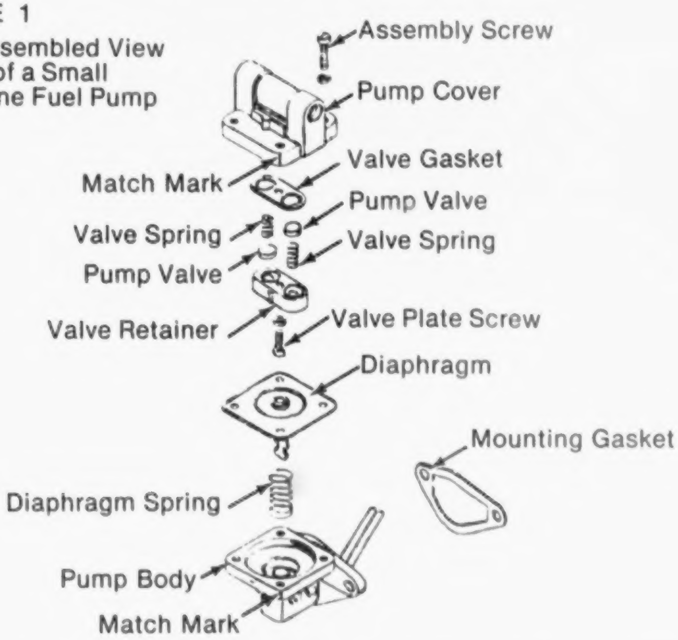
   (NOTE: Most fuel pumps are serviced by complete replacement.)

JOB SHEET #6

7. Using the correct repair kit and following manufacturer's repair information, rebuild the fuel pump (Figure 1)

FIGURE 1

Disassembled View of a Small Engine Fuel Pump


Assembly Screw
Pump Cover
Valve Gasket
Match Mark
Pump Valve
Valve Spring
Valve Spring
Pump Valve
Valve Retainer
Valve Plate Screw
Diaphragm
Mounting Gasket
Diaphragm Spring
Pump Body
Match Mark

8. Mark the pump cover and body with a file; this prevents reversing the cover as it goes on the body

9. Replace pump

10. Clean up work area and replace tools in proper place

11. Have instructor check work

FUEL SYSTEMS
UNIT IV-D

JOB SHEET #7 — SERVICE SEDIMENT BOWL FUEL STRAINER

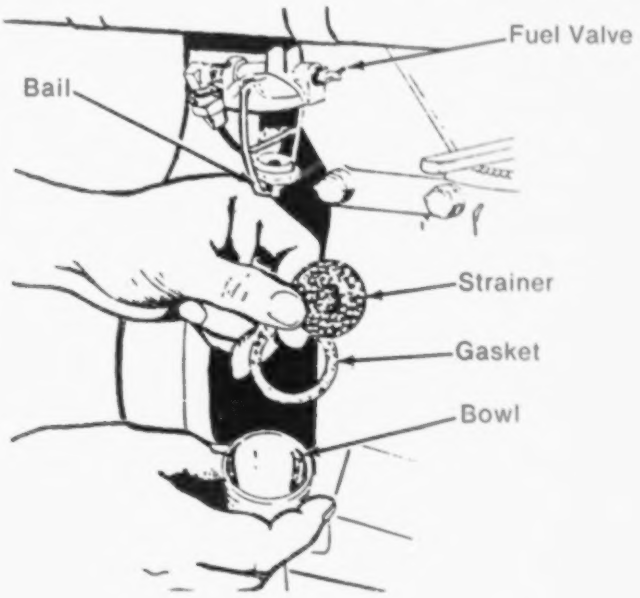
A. Tools and materials needed

1. Hand tool assortment
2. Solvents
3. Pan for cleaning parts
4. Cleaning rags
5. New gasket for glass bowl
6. Safety glasses

B. Procedure

1. Disconnect and ground spark plug wire
2. Close fuel shut-off valve
3. Loosen jam nut and swing the wire bail to one side (Figure 1)
4. Remove bowl with a twisting motion (Figure 1)

FIGURE 1



JOB SHEET #7

5. Remove gasket (Figure 1)

6. Remove strainer (filter) screen (Figure 1)

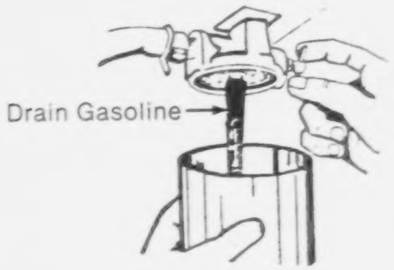
7. Wash the screen or filter element

8. Clean and then dry sediment bowl

9. Open fuel valve and drain out approximately a cup of fuel (Figure 2)

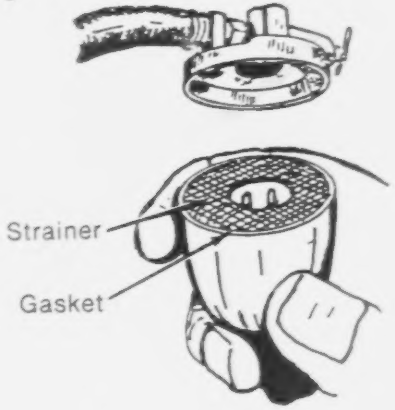
   (NOTE: Collect fuel in can to avoid a fire hazard.)

   FIGURE 2



10. Install gasket, strainer, and sediment bowl (Figure 3)

    FIGURE 3



11. Fill the sediment bowl before tightening the jam nut

12. Tighten bowl against gasket with jam nut

    (CAUTION: Do not overtighten.)

JOB SHEET #7

13. Check for leaks before operating engine
14. Reconnect spark plug wire to spark plug
15. Operate engine for a few minutes and recheck for leaks

FUEL SYSTEMS
UNIT IV-D

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

   _____a. Correct proportion of fuel and air needed for good combustion

   _____b. Restriction in the carburetor which makes the air speed up, causing a high vacuum

   _____c. Breaking of a liquid into tiny particles or globules to aid vapor formation

   _____d. Tube in a stream of air inside the venturi which creates an air pattern with low pressure on one side

   _____e. Transferring a substance into a gaseous state

   1. Venturi
   2. Airfoil
   3. Atomization
   4. Vaporization
   5. Metering

2. State the purpose of the fuel system.

   ____

   ____

3. List the three basic types of small engine fuel supply systems.

   a. ____

   b. ____

   c. ____

TEST

4. Match the components of the fuel system on the right with their correct functions.

______a. Acts as a reservoir to store fuel for engine use

______b. Prevents dirt or foreign matter from entering the carburetor

______c. Mixes fuel and air in the proper proportion for a combustible mixture

______d. Pumps fuel from the fuel tank to the carburetor

______e. Carries fuel from the fuel tank to the carburetor

______f. Filters grit and dust from the air entering the carburetor

______g. Sheet of metal or other material that is sufficiently flexible to permit vibration

1. Fuel line
2. Fuel tank
3. Carburetor
4. Pump diaphragm
5. Fuel filter
6. Air cleaner
7. Fuel pump

5. List the two types of carburetors.

a. ____

b. ____

6. Select types of fuel filters by placing an "X" in the appropriate blanks.

______a. Gravity feed

______b. Glass sediment bowl and screen

______c. Screen in fuel tank

______d. Filter attached to the end of flexible fuel hose

______e. Oil bath

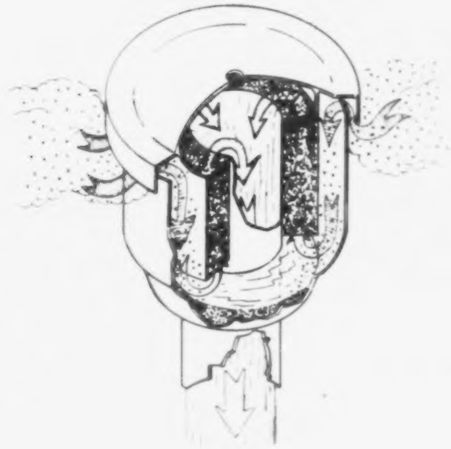
7. Distinguish between types of fuel pump action by placing an "X" next to the characteristics of inlet stroke action.

______a. Diaphragm pushed upward by return spring; inlet valve forced shut; outlet valve forced open; fuel is forced out of pump

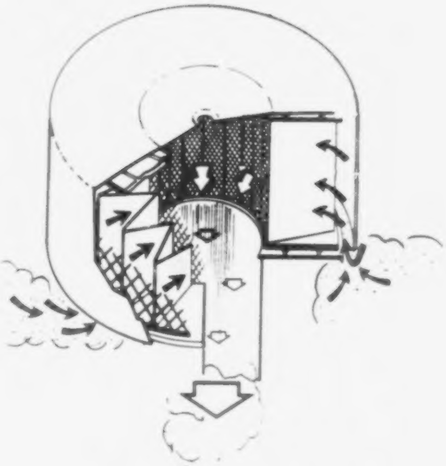
______b. Diaphragm flexes downward, forming a vacuum; inlet check valve opens; fuel is drawn into pump

TEST

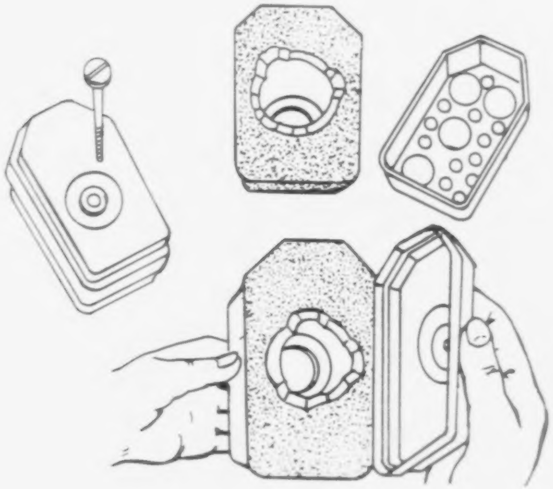
8. Identify three types of air cleaners.



a. ______________________________



b. ______________________________

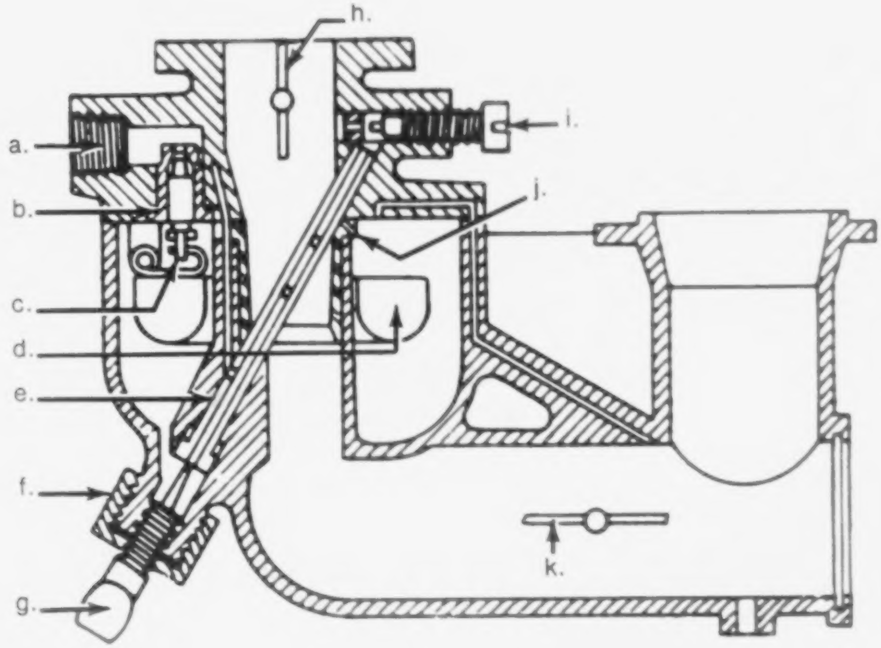


c. ______________________________

TEST

9. Identify parts of the float-type carburetor.

a. ____________________
b. ____________________
c. ____________________
d. ____________________
e. ____________________
f. ____________________
g. ____________________
h. ____________________
i. ____________________
j. ____________________
k. ____________________


h.
i.
a.
j.
b.
c.
d.
e.
f.
k.
g.

TEST

10. Identify parts of the diaphragm type carburetor.

a. ______________________

b. ______________________

c. ______________________

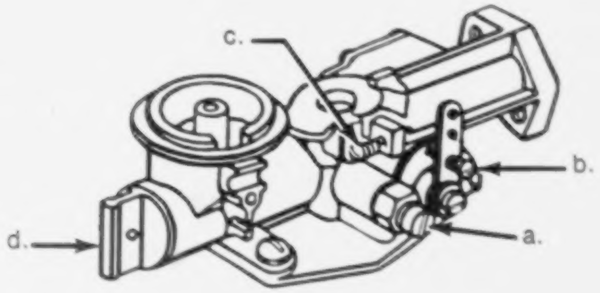
d. ______________________

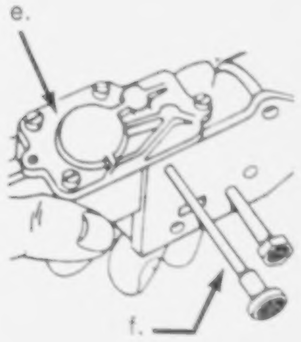
e. ______________________

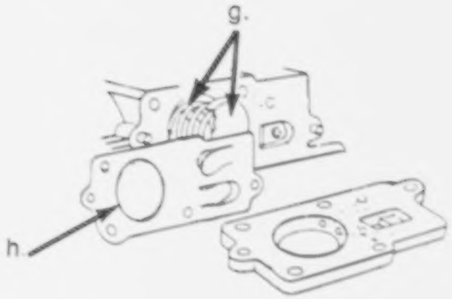
f. ______________________

g. ______________________

h. ______________________







TEST

11. Match the carburetor systems on the right with their correct uses.

_____a. Used when the engine is called upon to supply power for full, partial, or no-load at various operating speeds

_____b. Used to control the speed or power of an engine according to the requirements of the job it is to perform

_____c. Maintains a given depth of fuel in the float chamber

_____d. Provides a richer mixture for cold engine starting and operation

_____e. Provides fuel delivery during closed or nearly closed throttle operation

1. Float
2. Choke
3. High speed
4. Idle speed
5. Throttle

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

12. Demonstrate the ability to:

a. Service an air cleaner (Job Sheet #1).

b. Remove and replace a float-type carburetor (Job Sheet #2).

c. Service a float-type carburetor (Job Sheet #3).

d. Remove, service, and replace a diaphragm-type carburetor (Job Sheet #4).

e. Remove and replace a fuel pump (Job Sheet #5).

f. Test and service a fuel pump (Job Sheet #6).

g. Service sediment bowl fuel strainer (Job Sheet #7).

FUEL SYSTEMS
UNIT IV-D

ANSWERS TO TEST

1. a. 5
   b. 1
   c. 3
   d. 2
   e. 4

2. The fuel system supplies a combustible mixture of air and fuel vapor to the engine cylinders

3. a. Gravity feed
   b. Suction feed
   c. Pump feed

4. a. 2
   b. 5
   c. 3
   d. 7
   e. 1
   f. 6
   g. 4

5. a. Float
   b. Diaphragm

6. b,c,d

7. b

8. a. Oil bath
   b. Paper element
   c. Polyurethane

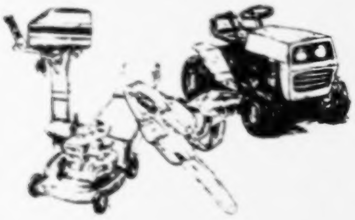
9. a. Fuel inlet
   b. Float needle seat
   c. Float needle
   d. Float
   e. Nozzle
   f. Packing nut
   g. Needle valve
   h. Throttle valve
   i. Idle valve
   j. Venturi
   k. Choke valve

10. a. Needle valve
    b. Speed adjusting screw
    c. Idle adjusting screw
    d. Choke
    e. Pump cover
    f. Fuel pipes
    g. Spring and cap
    h. Diaphragm

ANSWERS TO TEST

11.
- a. 3
- b. 5
- c. 1
- d. 2
- e. 4

12. Performance skills evaluated according to standards identified by the instructor



Governor Systems
Unit V-D

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify components of the governor system and inspect, adjust, and repair the governor system. Competencies will be demonstrated by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to the governor system with their correct definitions.
2. Select purposes of the governor system.
3. List two types of governor systems.
4. Identify the components of the governor systems.
5. Match the components of the governor systems with their correct purposes.
6. Demonstrate the ability to:
    a. Inspect, adjust, and repair an air vane governor (Job Sheet #1).
    b. Inspect and adjust external components of a mechanical governor with internal flyweights (Job Sheet #2).
    c. Repair internal components of a mechanical governor with internal flyweights (Job Sheet #3).

GOVERNOR SYSTEMS
UNIT V-D

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets prior to the demonstration of the procedures.

H. Integrate the following activities throughout the teaching of this unit:

1. Display examples of both types of governors.
2. If possible, collect several governors that show various types of problems.
3. Have students locate components of governor systems on live engines.
4. Demonstrate and discuss the procedures outlined in the job sheets.
5. Assist students in evaluation of their completed units of instruction and indicate to them possible areas of improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

SUGGESTED ACTIVITIES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

  1. TM 1 — Components of an Air Vane Governor System
  2. TM 2 — Components of a Mechanical Governor System

E. Job sheets

  1. Job Sheet #1 — Inspect, Adjust, and Repair an Air Vane Governor
  2. Job Sheet #2 — Inspect and Adjust External Components of a Mechanical Governor with Internal Flyweights
  3. Job Sheet #3 — Repair Internal Components of a Mechanical Governor with Internal Flyweights

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Small Engines, Volume 2.* Athens, Georgia: American Association for Vocational Instructional Materials.

B. *Small Engines Service Manual.* Eleventh Edition. Kansas City, Missouri: Intertec Publishing Corp., 1976.

C. Herd, Amon, *Governor Adjustment and Repair.* Columbia, Missouri: Instructional Materials Laboratory, University of Missouri-Columbia.

D. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

GOVERNOR SYSTEMS
UNIT V-D

INFORMATION SHEET

I. **Terms and definitions**

A. Centrifugal force — A force which tends to move a body away from its center of rotation

Example: A whirling weight attached to a string

B. Pneumatic — Moved or worked by air

C. Throttle — Lever controlling the throttle valve by linkage and spring adjustment

D. Vane — Thin flat object that pivots about an axis by a flow of air

E. Linkage — Series of rods, yokes, and levers used to transmit motion from one unit to another

II. **Purposes of the governor system**

A. Maintains selected speed

B. Prevents overspeeding that may cause engine damage

C. Limits both high and low speeds

III. **Types of governor systems** (Transparencies 1 and 2)

A. Air vane

(NOTE: The air vane system operates by directing the air from the flywheel against the air vane.)

B. Mechanical (centrifugal)

(NOTE: The mechanical system operates by the use of centrifugal weights working against a spring.)

IV. **Components of the governor system** (Transparencies 1 and 2)

A. Air vane governor

1. Throttle control

2. Control spring

INFORMATION SHEET

   3. Air vane
   4. Throttle linkage
   5. Flywheel

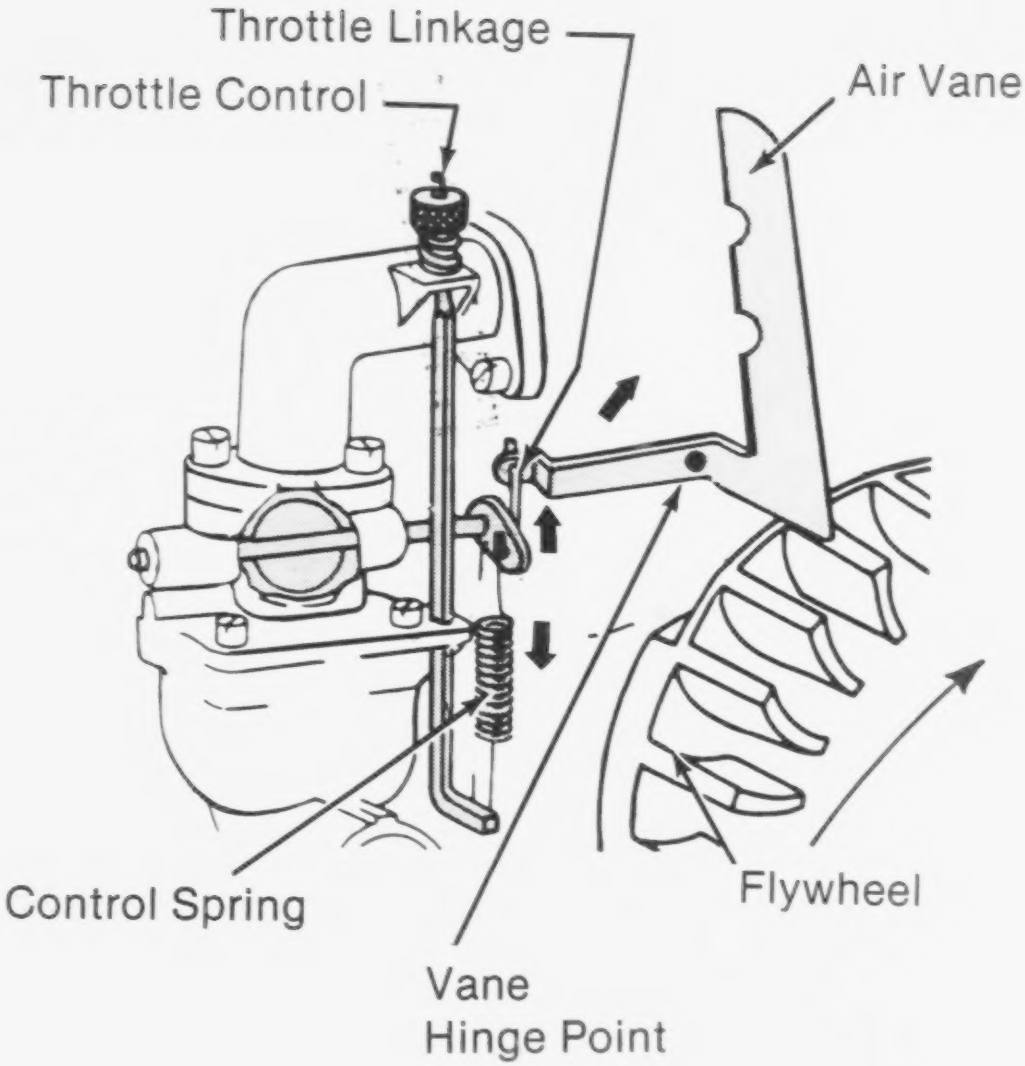
  B. Mechanical (centrifugal governor)
   1. Throttle control
   2. Throttle rod
   3. Throttle linkage
   4. Control spring
   5. Control arm
   6. Flyweights
   7. Throttle shaft

V. Purposes of each component of the governor systems

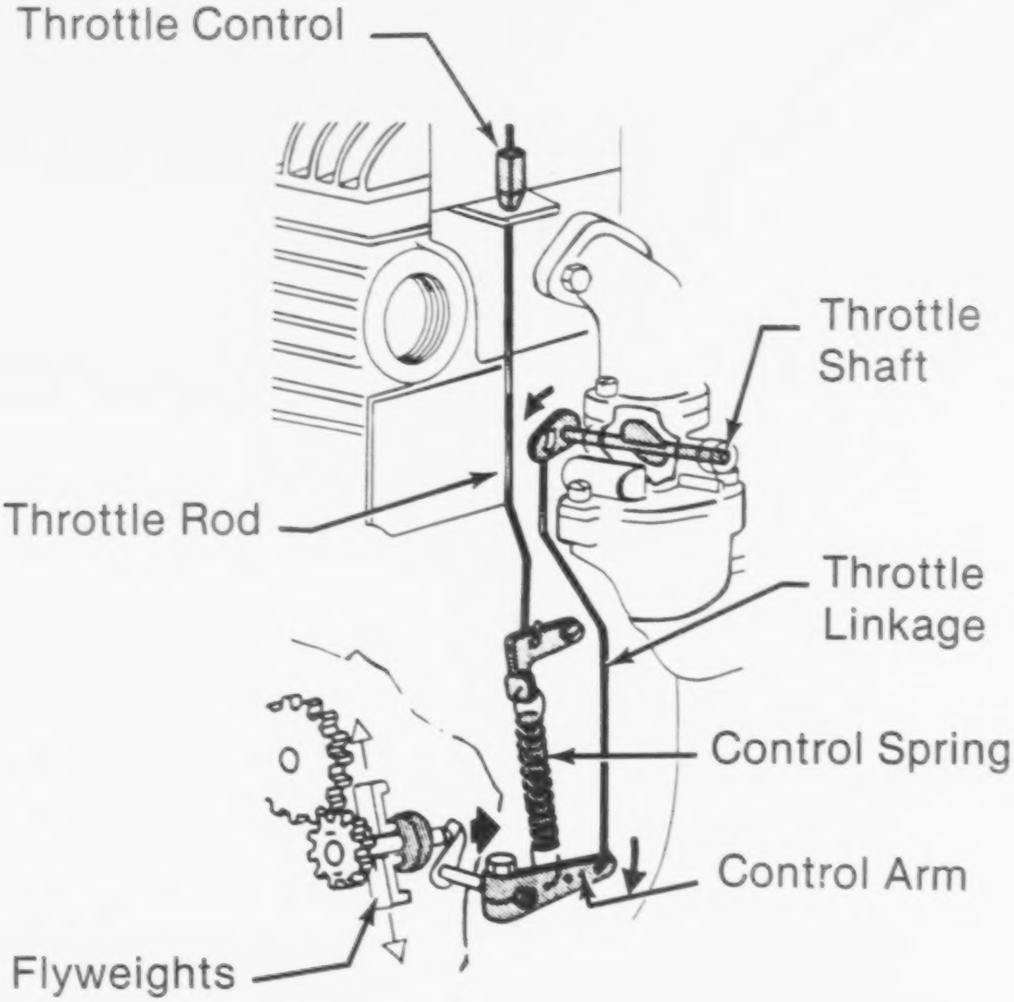
  A. Air vane governor
   1. Throttle control — Regulates engine speed
   2. Control spring — Connection between throttle control and throttle valve shaft
   3. Air vane — Senses air movement and opens or closes throttle
   4. Linkage — Connects air vane to the throttle valve shaft
   5. Flywheel — Provides pneumatic pressure in relationship to engine rpm

  B. Mechanical governor
   1. Throttle control — Regulates engine speed
   2. Throttle rod — Transfers control adjustments to control spring
   3. Throttle linkage — Connects control arm to throttle shaft
   4. Control spring — Provides tension to control arm
   5. Control arm — Transfers flyweight action to throttle link
   6. Flyweights — Senses engine rpm and controls governor control arm

Components of an Air Vane Governor System


Throttle Linkage
Throttle Control
Air Vane
Control Spring
Flywheel
Vane
Hinge Point

Components of a Mechanical Governor System


Throttle Control
Throttle Shaft
Throttle Rod
Throttle Linkage
Control Spring
Control Arm
Flyweights

GOVERNOR SYSTEMS
UNIT V-D

JOB SHEET #1 — INSPECT, ADJUST, AND REPAIR AN AIR VANE GOVERNOR

A. Tools and materials needed

1. Hand tool assortment
2. Tachometer

   (NOTE: A vibration tach or impulse tach may be used.)

3. Safety glasses
4. Appropriate service manual

B. Procedure

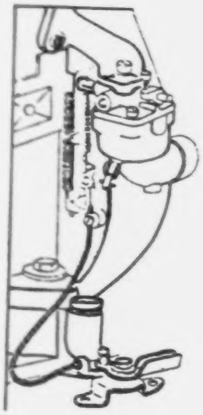
1. Remove breather or air cleaner

   (NOTE: This may not be necessary in all cases, yet it usually will give a better view of linkage.)

2. Remove blower shroud
3. Check the condition of the linkage and controllers (Figure 1)

   (NOTE: Look for bent control rods, stretched springs, and pivot points where binding may occur. Straighten, lubricate, and replace parts as necessary. Always replace stretched springs.)

FIGURE 1



JOB SHEET #1

4. Check air vane for freedom of movement and positioning

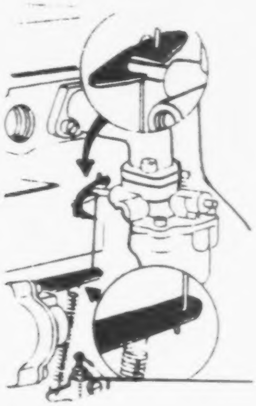
   (NOTE: Vane should be parallel to the crankshaft. Replace damaged parts as needed.)

5. Replace blower shroud

6. Check to see if throttle valve is open while engine is not running

   (NOTE: If valve is not open, check for binding. If no binds exist adjust spring tension until valve is open. See Figure 2)

   FIGURE 2



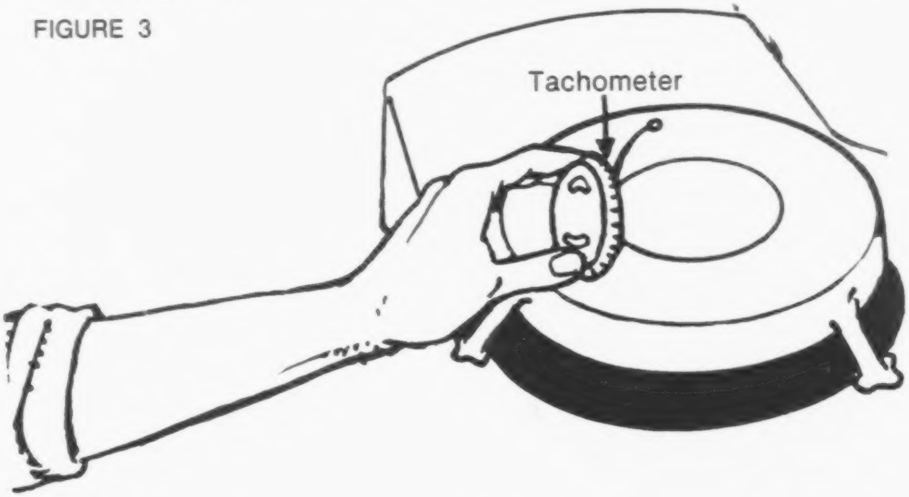
7. Replace breather

8. Find engine recommended speeds in manufacturer's service manual

9. Start engine

10. Check engine low idle speed with tachometer while throttle control is in closed position (Figure 3)

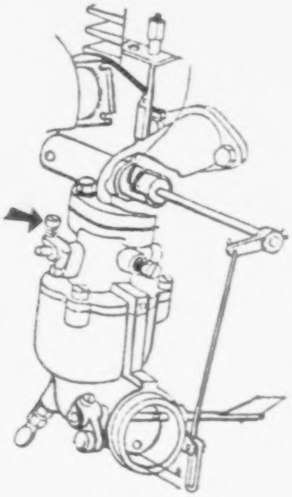
    FIGURE 3



JOB SHEET #1

(NOTE: Check against manufacturer's specifications. Adjust idle stop screw at carburetor if your reading is not consistent with manufacturer's specifications. See Figure 4.)

FIGURE 4



11. Check engine high idle no-load speed with tachometer while throttle control is fully open

    (NOTE: Check against manufacturer's specifications. If engine overspeeds or surges, the spring is too tight. If engine will not come up to speed, spring is too loose. Adjust to manufacturer's specifications.)

12. Shut off engine

13. Have instructor evaluate work

GOVERNOR SYSTEMS
UNIT V-D

JOB SHEET #2 — INSPECT AND ADJUST EXTERNAL COMPONENTS OF A MECHANICAL GOVERNOR WITH INTERNAL FLYWEIGHTS

A. Tools and materials needed

1. Hand tool assortment
2. Tachometer
3. Appropriate service manual
4. Safety glasses

B. Procedure

(NOTE: Before disassembling engines to repair internal flyweights be sure that the fuel system and external governor components have thoroughly been inspected.)

1. Remove breather

   (NOTE: This may not be necessary in all cases, however it usually will give a better view of linkage.)

2. Check condition of linkage and controllers

   (NOTE: Look for bent control rods, stretched springs, and pivot points where binding may occur. Straighten, lubricate, and replace parts as necessary. Always replace stretched springs.)

3. Check to see if throttle valve is open while engine is at rest

4. Adjust throttle to open position if necessary (Figure 1)

   a. Loosen screw clamping control arm to governor rod

   b. Turn control arm until carburetor throttle is in wide open position

      (NOTE: Check appropriate service manual for direction of rotation.)

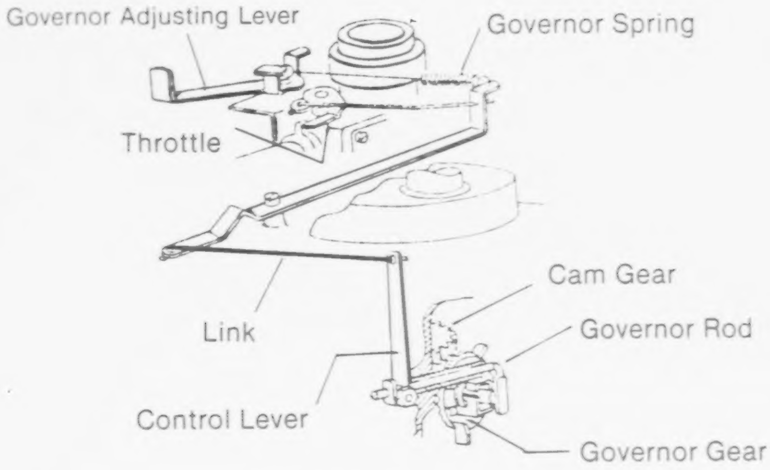
   c. Turn crank on governor rod counterclockwise as far as possible

   d. Tighten screw connecting control arm to governor rod

JOB SHEET #2

e. Check linkage for freedom

FIGURE 1


Governor Adjusting Lever
Governor Spring
Throttle
Cam Gear
Governor Rod
Link
Control Lever
Governor Gear

5. Find recommended engine speeds in service manuals

6. Replace breather or air cleaner

7. Start engine

8. Check engine low idle speed with tachometer while engine throttle control is in closed position

   (NOTE: Adjust idle stop screw at carburetor if idle speed does not correspond with manufacturer's specification.)

9. Check engine high idle no-load with tachometer while engine control level is in full throttle position

   (NOTE: If engine overspeeds or surges, spring is too tight. If engine will not come up to speed, the spring is too loose. Adjust to manufacturer's specifications. Be sure carburetor is properly adjusted.)

10. Shut off engine

11. Have instructor evaluate work

GOVERNOR SYSTEMS
UNIT V-D

JOB SHEET #3 — REPAIR INTERNAL COMPONENTS OF A MECHANICAL GOVERNOR WITH INTERNAL FLYWEIGHTS

A. Tools and materials needed

1. Hand tool assortment
2. Oil drain pan
3. Shop towels
4. Fresh oil
5. Solvent
6. Parts cleaning brush
7. Water supply and hose
8. Safety glasses

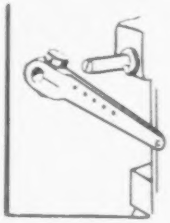
B. Procedure

1. Remove engine from equipment
2. Place engine oil reservoir drain plug over drain pan
3. Remove plug and drain oil

   (NOTE: Dispose of used oil properly.)
4. Replace plug
5. Clean engine exterior with solvent and brush

   (NOTE: Allow solvent to penetrate hard deposits.)
6. Hose off solvent and dirt
7. Loosen securing bolt and disconnect control lever from governor rod (Figure 1)

FIGURE 1



JOB SHEET #3

8. Remove side housing bolts
9. Remove governor unit

   (NOTE: Internal governor units come in a variety of styles, however basic components are quite similar. See Figures 2 and 3.)

FIGURE 2

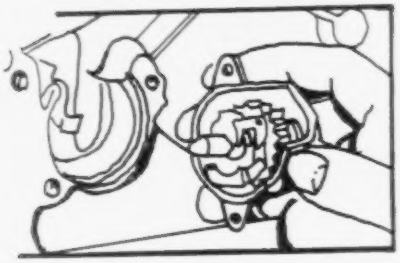
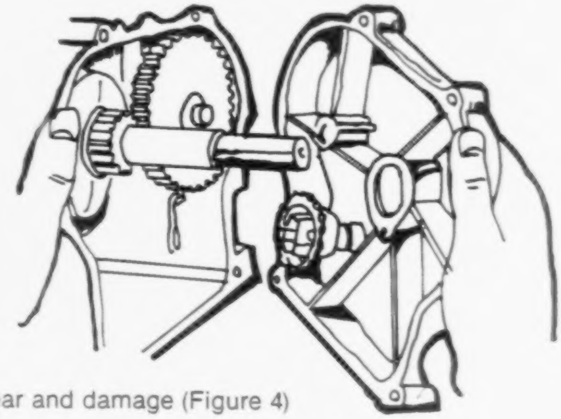
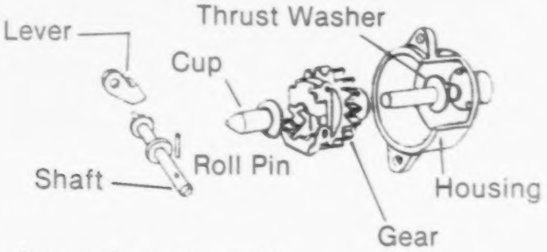


FIGURE 3



10. Check governor unit for wear and damage (Figure 4)

FIGURE 4



11. Replace damaged or worn parts

    (NOTE: Check thrustwashers for wear or damage.)
12. Reinstall governor unit on the housing
13. Place housing back on the engine block

    (NOTE: Replace gasket if torn or damaged, and refer to appropriate service manual for bolt torque specifications.)
14. Install the housing bolts
15. Put control lever on governor rod
16. Put oil in engine
17. Adjust external components

GOVERNOR SYSTEMS
UNIT V-D

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

   _____a. Moved or worked by air

   _____b. Thin flat object that pivots about an axis by a flow of air

   _____c. Series of rods, yokes, and levers used to transmit motion from one unit to another

   _____d. A force which tends to move a body away from its center of rotation

   _____e. Lever controlling the throttle valve by linkage and spring adjustment

   1. Linkage
   2. Pneumatic
   3. Vane
   4. Centrifugal force
   5. Throttle

2. Select purposes of the governor system by placing an "X" in the appropriate blanks.

   _____a. Maintains selected speed

   _____b. Prevents overspeeding that may cause engine damage

   _____c. Limits both high and low speeds

3. List two types of governor systems.

   a. ____

   b. ____

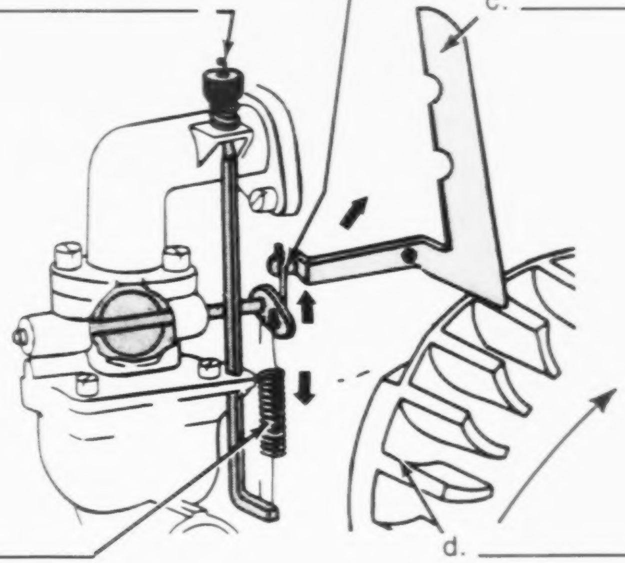
TEST

4. Identify the components of the governor systems.

b. ____________________

a. ____________________

c. ____________________

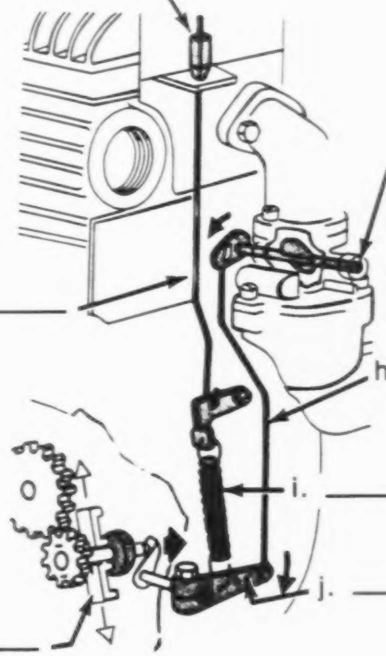


e. ____________________

d. ____________________

f. ____________________

g. ____________________



l. ____________________

h. ____________________

i. ____________________

j. ____________________

k. ____________________

TEST

5. Match the components of the governor systems on the right with their correct purposes.

a. Air vane

______1) Connection between throttle control and throttle valve shaft

______2) Connects air vane to the throttle valve shaft

______3) Provides pneumatic pressure in relationship to engine rpm

______4) Senses air movement and opens or closes throttle

______5) Regulates engine speed

a) Control spring
b) Flywheel
c) Linkage
d) Air vane
e) Throttle control

b. Mechanical

______1) Transfers control adjustments to control spring

______2) Provides tension to control arm

______3) Senses engine rpm and controls governor control arm

______4) Regulates engine speed

______5) Connects control arm to throttle shaft

______6) Transfers flyweight action to throttle link

a) Flyweights
b) Control arm
c) Control spring
d) Throttle linkage
e) Throttle rod
f) Throttle control

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

6. Demonstrate the ability to:

a. Inspect, adjust, and repair an air vane governor (Job Sheet #1).

b. Inspect and adjust external components of a mechanical governor with internal flyweights (Job Sheet #2).

c. Repair internal components of a mechanical governor with internal flyweights (Job Sheet #3).

GOVERNOR SYSTEMS
UNIT V-D

ANSWERS TO TEST

1. a. 2
   b. 3
   c. 1
   d. 4
   e. 5

2. a,b,c

3. a. Air vane
   b. Mechanical (centrifugal)

4. a. Throttle control
   b. Throttle linkage
   c. Air vane
   d. Flywheel
   e. Control spring
   f. Throttle control
   g. Throttle shaft
   h. Throttle linkage
   i. Control spring
   j. Control arm
   k. Flyweights
   l. Throttle rod

5. a. 1) a
      2) c
      3) b
      4) d
      5) e
   b. 1) e
      2) c
      3) a
      4) f
      5) d
      6) b

6. Performance skills evaluated according to standards identified by the instructor

Exhaust Systems
Unit VI-D

UNIT OBJECTIVE

After completion of this unit, the student should be able to select types of exhaust systems and remove, service, and replace two cycle exhaust system components. Competencies will be demonstrated by correctly performing the procedures outlined in the job sheet and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to the exhaust system with their correct definitions.
2. List two results that can occur from running a worn or damaged exhaust system.
3. Select the types of exhaust systems.
4. State the danger of operating an engine in a closed shop.
5. Demonstrate the ability to remove, service, and replace two cycle exhaust system components (Job Sheet #1).

EXHAUST SYSTEMS
UNIT VI-D

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Provide students with objective sheet.

C. Discuss unit and specific objectives.

D. Provide students with information sheet.

E. Discuss the information sheet.

F. Provide students with job sheet prior to the demonstration of the procedure.

G. Integrate the following activities throughout the teaching of this unit:

1. Provide cutaway of an exhaust system and explain its operation.
2. Discuss variations in exhaust systems with class.
3. Compare good and bad exhaust systems.
4. Show internal component damage due to a poor exhaust system.
5. Demonstrate and discuss the procedure outlined in the job sheet.
6. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

H. Give test.

I. Evaluate test.

J. Reteach if necessary.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Job Sheet #1 — Remove, Service, and Replace Two Cycle Exhaust System Components

SUGGESTED ACTIVITIES

E. Test

F. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Small Engines, Volume 1*. Athens, Georgia: American Association for Vocational Instructional Materials.

B. Crouse, William H. and Donald L. Anglin. *Small Engine Mechanics*. Second Edition. New York: Gregg Division, McGraw-Hill Book Company, 1980.

C. *Comprehensive Small Engine Repair*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

EXHAUST SYSTEMS
UNIT VI-D

INFORMATION SHEET

I. **Terms and definitions**

A. Exhaust valve — Valve which seals burning gases within cylinder until its energy has been expended, then opens so the cylinder can clear

B. Exhaust manifold — Receives and carries away burned gases

C. Exhaust pipe — Pipe connecting exhaust manifold to muffler

D. Muffler — Carries away exhaust gases, muffles engine noise, and acts as a scavenger to recover unburned fuel

E. Tail pipe — Pipe from muffler that carries exhaust fumes away from equipment

F. Exhaust port — Hole in cylinder wall that allows exhaust gases to escape

II. **Results that can occur from running a worn or damaged exhaust system**

A. Loss of power

B. Ring and valve damage

III. **Types of exhaust systems**

A. Straight through

B. Reverse flow

C. Expansion chamber

IV. **The danger of operating an engine in a closed shop** — Exhaust gases contain carbon monoxide, a deadly poison

(NOTE: Engines should not be operated in a closed shop; proper ventilation should be used for running engines; and, ear protection should be worn at all times.)

EXHAUST SYSTEMS
UNIT VI-D

JOB SHEET #1 — REMOVE, SERVICE, AND REPLACE TWO CYCLE EXHAUST SYSTEM COMPONENTS

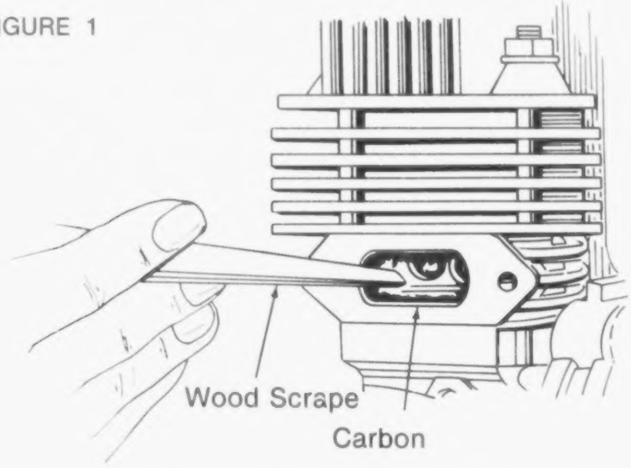
A. Tools and materials needed

1. Hand tool assortment
2. Hardwood scraper
3. Carbon solvent
4. Compressed air
5. Safety glasses

B. Procedure

1. Remove muffler and any mounting gaskets (Figure 1)

FIGURE 1



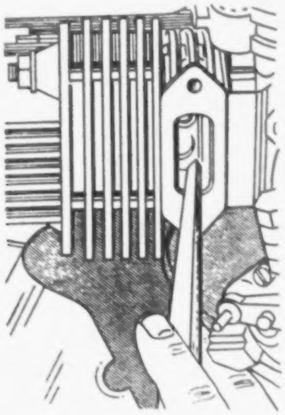
2. Rotate crankshaft until piston covers exhaust ports

JOB SHEET #1

3. Using the wood scraper remove carbon from ports (Figure 2)

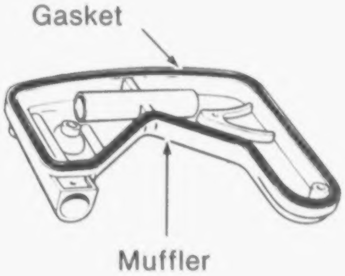
   (NOTE: Do not use a metal scraper as this will scratch the piston or damage the exhaust port edges.)

   FIGURE 2



4. Hold engine with port down so carbon will fall out
5. Blow out the ports with compressed air
6. Soak muffler in solvent to remove carbon deposits

   FIGURE 3



(NOTE: The gasket should be replaced when servicing muffler.)

JOB SHEET #1

7. Wash muffler with warm water

8. Reinstall muffler using new gaskets where needed

   (NOTE: When installing mufflers on four cycle engines, use a locknut to prevent seizing of the muffler in the block. Discard damaged or worn out system components. Use anti-seize compound on bolts.)

9. Have instructor evaluate work

EXHAUST SYSTEMS
UNIT VI-D

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

______a. Valve which seals burning gases within cylinder until its energy has been expended, then opens so the cylinder can clear

______b. Receives and carries away burned gases

______c. Pipe connecting exhaust manifold to muffler

______d. Carries away exhaust gases and heat, muffles engine noise, and acts as a scavenger to recover unburned fuel

______e. Pipe from muffler that carries exhaust fumes away from equipment

______f. Hole in cylinder wall that allows exhaust gases to escape

1. Exhaust manifold
2. Muffler
3. Tail pipe
4. Exhaust pipe
5. Exhaust port
6. Exhaust valve

2. List two results that can occur from running a worn or damaged exhaust system.

a. ____

b. ____

3. Select the types of exhaust systems by placing an "X" in the appropriate blanks.

______a. Diagonal flow

______b. Straight through

______c. Looped flow

______d. Expansion chamber

______e. Reverse flow

TEST

4. State the danger of operating an engine in a closed shop.

____

____

____

(NOTE: If the following activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

5. Demonstrate the ability to remove, service, and replace two cycle exhaust system components (Job Sheet #1).

EXHAUST SYSTEMS
UNIT VI-D

ANSWERS TO TEST

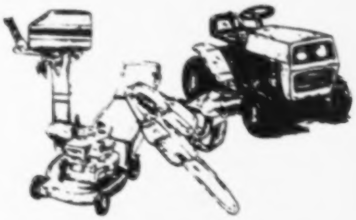
1. a. 6
   b. 1
   c. 4
   d. 2
   e. 3
   f. 5

2. a. Loss of power
   b. Possible engine damage

3. b,d,e

4. Exhaust gases contain carbon monoxide, a deadly poison

5. Performance skills evaluated according to standards identified by the instructor



Troubleshooting
Unit VII-D

UNIT OBJECTIVE

After completion of this unit, the student should be able to solve problems using the troubleshooting chart and troubleshoot engine problems. Competencies will be demonstrated by correctly performing the procedures outlined in the assignment and job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Define troubleshooting.
2. Select requirements for an engine to run.
3. Complete a list of basic troubleshooting procedures.
4. Select true statements concerning the importance of understanding troubleshooting procedures.
5. Solve problems using the small engine troubleshooting chart (Assignment Sheet #1).
6. Demonstrate the ability to:
    a. Troubleshoot the fuel system (Job Sheet #1).
    b. Troubleshoot the ignition system (Job Sheet #2).
    c. Troubleshoot engine compression (Job Sheet #3).

TROUBLESHOOTING
UNIT VII-D

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparency.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparency to enhance the information as needed.)

G. Provide students with assignment and job sheets prior to the demonstration of the procedures.

H. Integrate the following activities throughout the teaching of this unit:

   1. Show students examples of troubleshooting charts from service manuals and discuss their use.
   2. Invite a potential employer to discuss the importance of sound troubleshooting techniques.
   3. Take students on a field trip to visit shop and observe troubleshooting techniques.
   4. Discuss procedure outlined in the assignment sheet.
   5. Demonstrate and discuss the procedures outlined in the job sheets.
   6. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

SUGGESTED ACTIVITIES

K. Reteach if necessary.

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency Master 1 — Small Engine Troubleshooting Chart

E. Assignment Sheet #1 — Solve Problems Using the Small Engine Troubleshooting Chart

F. Answers to assignment sheet

G. Job sheets

   1. Job Sheet #1 — Troubleshoot the Fuel System

   2. Job Sheet #2 — Troubleshoot the Ignition System

   3. Job Sheet #3 — Troubleshoot Compression

H. Test

I. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Hydraulics*. Moline, Illinois: Deere and Company, 1979.

B. *Chilton's Motorcycle Troubleshooting Guide*. Radnor, Pennsylvania: Chilton Book Company, 1973.

C. *Comprehensive Small Engine Repair*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

D. Herd, Amon. *Troubleshooting Small Engines*. Columbia, Missouri: Instructional Materials Laboratory, University of Missouri-Columbia.

E. Herd, Amon. *Maintenance Procedures*. Columbia, Missouri: Instructional Materials Laboratory, University of Missouri-Columbia.

TROUBLESHOOTING
UNIT VII-D

INFORMATION SHEET

I. **Troubleshooting** — The systematic diagnosis of engine malfunctions

II. **Requirements for an engine to run**

   A. Compression

   B. Ignition

   C. Carburetion

   (NOTE: Troubleshooting involves checking for sufficient compression, proper ignition, and adequate fuel to the combustion chamber. All engine troubles fall into these categories.)

III. **Basic troubleshooting procedures**

   A. Know the engine

   (NOTE: This may involve the study of an engine's service manual if you are not already familiar with its design features. A good service person keeps up with the latest service bulletins.)

   B. Ask the operator

   (NOTE: Important questions you should ask the customer or operator include:

      1. When was the equipment last used?
      2. Does the engine start?
      3. Does it stall out?
      4. Is the engine hard to start?
      5. Is anything broken?
      6. Does the engine lack power under load?
      7. Does the engine overheat?
      8. Is the engine noisy?
      9. Does the engine vibrate?)

INFORMATION SHEET

C. Inspect the engine

(NOTE: Check level and condition of oil, level and condition of fuel, and coolant level if equipped. Look for clogged breathers and fuel system vent caps, loose hoses, manifolds, and wire connections while inspecting.)

D. Operate the engine if possible

(NOTE: Listen to the sounds it makes while running as well as looking for erratic behavior, oil leaks, or unusual emissions.)

E. List possible causes

(NOTE: Put down all the symptoms and visible possibilities.)

F. Formulate a conclusion

(NOTE: Remember when looking at the list of possible causes that one failure often leads to or indicates another problem.)

G. Test condition

(NOTE: Before you start repairing the engine, analyze the information you have and test your conclusion if possible. Be a troubleshooter, not a hit and miss person.)

IV. **Importance of understanding troubleshooting procedures**

A. Saves customer's money

(NOTE: The alternative to troubleshooting is parts exchanging. If you don't solve the problem on first or second exchange it gets expensive.)

B. Insures a better repair job

1. Total system or engine is observed

(NOTE: This provides more opportunity to find weak or failing parts.)

2. Better operating dependability

(NOTE: Thorough troubleshooting provides for the identification of problems which may hinder proper engine operations in the future.)

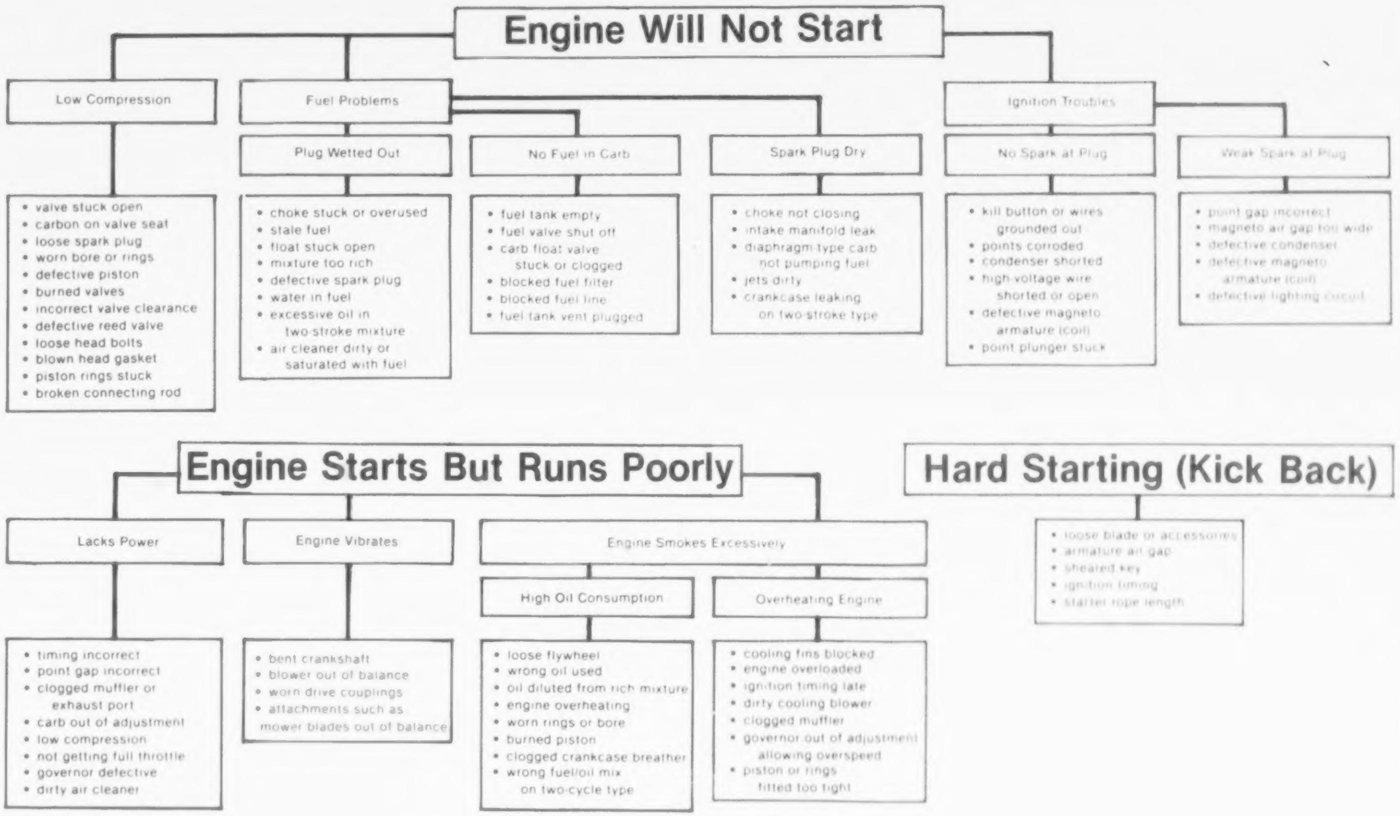
C. Makes employees more valuable

1. Good service means continued business with present customers plus the drawing of new customers

2. Less work is returned

V. **Small engine troubleshooting chart** (Transparency 1)

Small Engine Troubleshooting Chart



Engine Will Not Start

- Low Compression
  - valve stuck open
  - carbon on valve seat
  - loose spark plug
  - worn bore or rings
  - defective piston
  - burned valves
  - incorrect valve clearance
  - defective reed valve
  - loose head bolts
  - blown head gasket
  - piston rings stuck
  - broken connecting rod
- Fuel Problems
  - Plug Wetted Out
    - choke stuck or overused
    - stale fuel
    - float stuck open
    - mixture too rich
    - defective spark plug
    - water in fuel
    - excessive oil in two-stroke mixture
    - air cleaner dirty or saturated with fuel
  - No Fuel in Carb
    - fuel tank empty
    - fuel valve shut off
    - carb float valve stuck or clogged
    - blocked fuel filter
    - blocked fuel line
    - fuel tank vent plugged
  - Spark Plug Dry
    - choke not closing
    - intake manifold leak
    - diaphragm-type carb not pumping fuel
    - jets dirty
    - crankcase leaking on two-stroke type
- Ignition Troubles
  - No Spark at Plug
    - kill button or wires grounded out
    - points corroded
    - condenser shorted
    - high-voltage wire shorted or open
    - defective magneto armature (coil)
    - point plunger stuck
  - Weak Spark at Plug
    - point gap incorrect
    - magneto air gap too wide
    - defective condenser
    - defective magneto armature (coil)
    - defective lighting circuit

Engine Starts But Runs Poorly

- Lacks Power
  - timing incorrect
  - point gap incorrect
  - clogged muffler or exhaust port
  - carb out of adjustment
  - low compression
  - not getting full throttle
  - governor defective
  - dirty air cleaner
- Engine Vibrates
  - bent crankshaft
  - blower out of balance
  - worn drive couplings
  - attachments such as mower blades out of balance
- Engine Smokes Excessively
  - High Oil Consumption
    - loose flywheel
    - wrong oil used
    - oil diluted from rich mixture
    - engine overheating
    - worn rings or bore
    - burned piston
    - clogged crankcase breather
    - wrong fuel/oil mix on two-cycle type
  - Overheating Engine
    - cooling fins blocked
    - engine overloaded
    - ignition timing late
    - dirty cooling blower
    - clogged muffler
    - governor out of adjustment allowing overspeed
    - piston or rings fitted too tight

Hard Starting (Kick Back)

- loose blade or accessories
- armature air gap
- sheared key
- ignition timing
- starter rope length

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TROUBLESHOOTING
UNIT VII-D

ASSIGNMENT SHEET #1 — SOLVE PROBLEMS USING THE TROUBLESHOOTING CHART

Directions: Solve the problems below using the troubleshooting chart (Transparency 1) in this unit. Place answers in the blanks provided after each problem.

1. The equipment has been in use for 30 minutes and the engine shuts down.

   ____

   ____

2. The engine begins to vibrate excessively.

   ____

   ____

3. Engine has just received an ignition tuneup and was in top starting and running order when turned over to the customer. Two days later the customer could not start the engine.

   ____

   ____

4. Engine is hard to start and has a kick back.

   ____

   ____

5. No fuel in carburetor

   ____

   ____

6. Engine is beginning to lose power. (Two cycle)

   ____

   ____

TROUBLESHOOTING
UNIT VII-D

ANSWERS TO ASSIGNMENT SHEETS

1. Fuel problem; fuel tank vent plugged
2. Loose or bent blade; bent crankshaft
3. The ignition switch was in kill position
4. Out of time; armature air gap
5. Fuel valve shut off
6. Exhaust ports clogged

TROUBLESHOOTING
UNIT VII-D

JOB SHEET #1 — TROUBLESHOOT THE FUEL SYSTEM

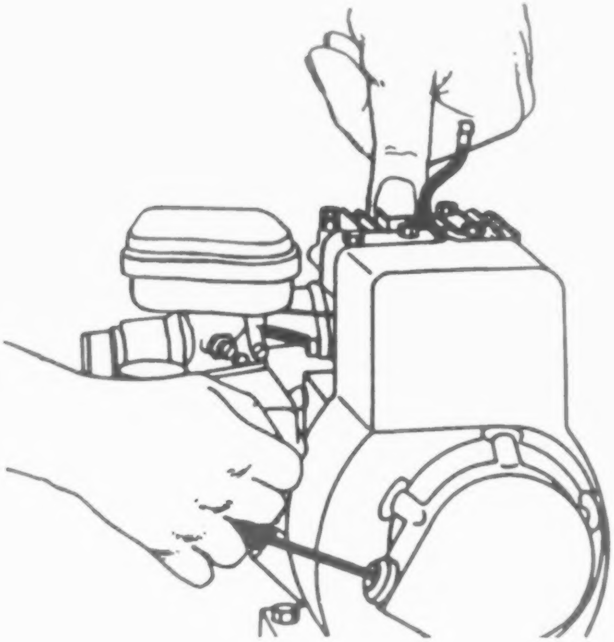
A. Tools and materials needed

1. Basic hand tool assortment
2. Appropriate service manual
3. Safety glasses

B. Procedure

1. Wear proper safety equipment
2. Read operator's manual
3. Organize work station
4. Remove the spark plug and place your thumb or finger over spark plug hole (Figure 1)

FIGURE 1



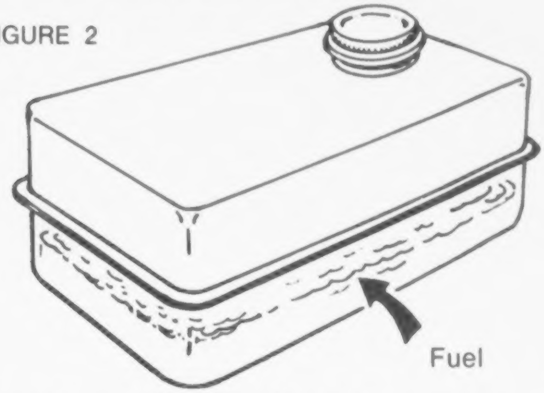
JOB SHEET #1

5. Pull the starter 2 to 3 times

   (NOTE: Your finger should be wet if fuel is getting to the combustion chamber. When finger is dry you will need to check further for a fuel problem.)

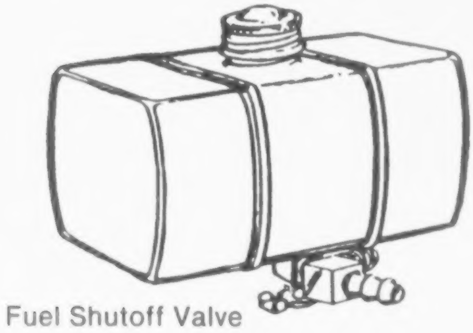
6. Check for fuel in the fuel tank (Figure 2)

FIGURE 2



7. Check to see if fuel shutoff valve is open (Figure 3)

FIGURE 3

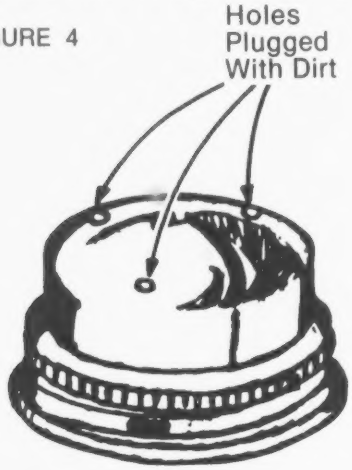


JOB SHEET #1

8. Check for plugged vents on fuel tank cap (Figure 4)

   (NOTE: A plugged vent will cause excessive vapor pressure to build up in the tank and result in engine stoppage.)

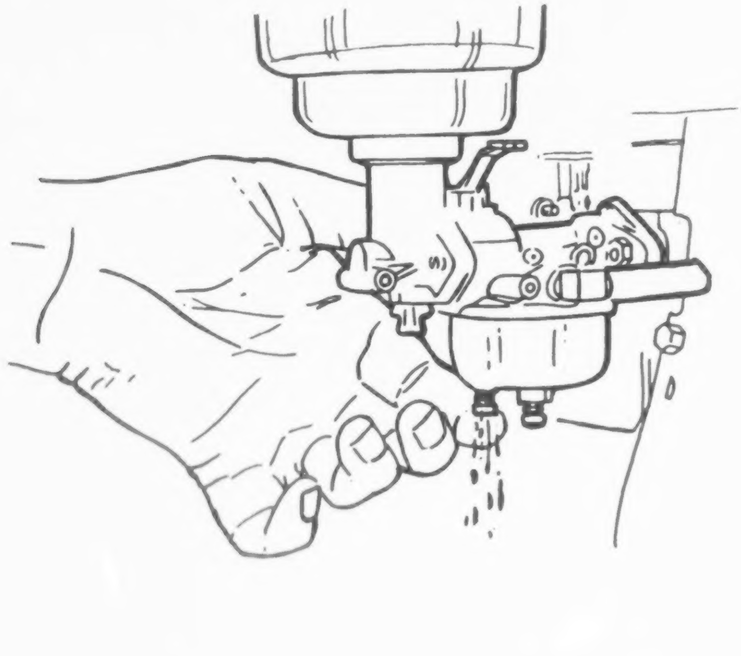
   FIGURE 4



9. If the carburetor is equipped with a bowl drain valve, press the valve and let a small amount of fuel drain out into a container (Figure 5)

   (NOTE: When fuel drains from the valve, this indicates that fuel is getting from the tank to the carburetor.)

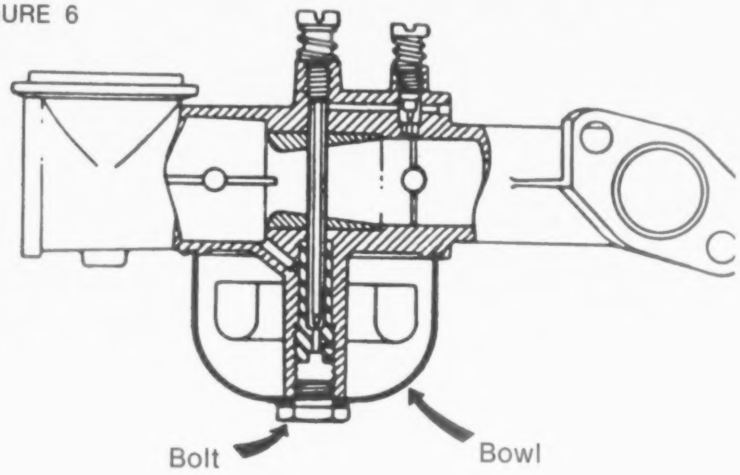
   FIGURE 5



JOB SHEET #1

10. If carburetor is not equipped with a drain valve, remove the bowl from the carburetor; loosen bolt or nut from bowl drain and check for gas in bowl (Figure 6)

FIGURE 6



(NOTE: When checking the carburetor bowl for fuel, always look for water or foreign matter in the fuel. If water or foreign matter is present, the carburetor will need to be serviced.)

11. If fuel does not drain out of the valve or is not present in the bowl, check the fuel tank, line, and carburetor as this indicates an obstruction

12. Check fuel filter for dirt or clogged element; remove and replace with a new in-line filter in any flexible fuel line having 1/4" inside diameter

13. Formulate problem and corrective measures

    a. Review list of probable causes

    b. Correct fuel problem

TROUBLESHOOTING
UNIT VII-D

JOB SHEET #2 — TROUBLESHOOT THE IGNITION SYSTEM

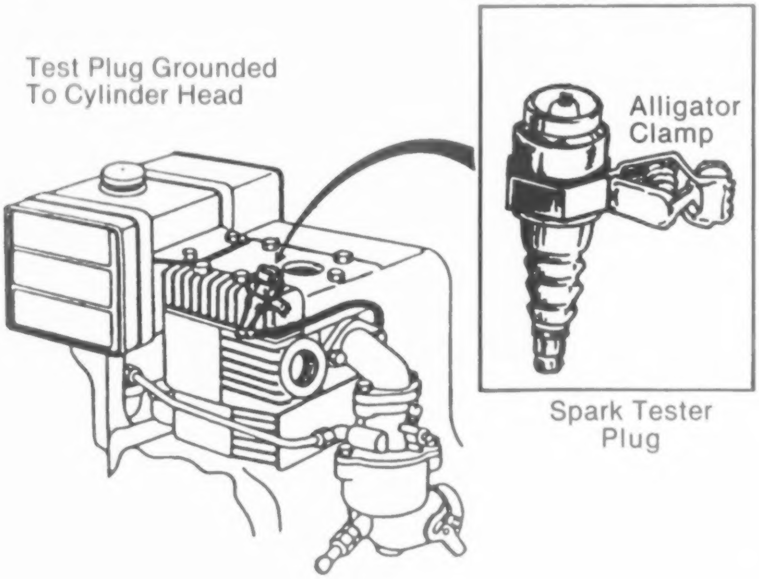
A. Tools and materials needed

1. Basic hand tool assortment
2. Test plug
3. Appropriate service manual
4. Safety glasses

B. Procedure

1. Wear proper safety equipment
2. Read operator's manual
3. Organize your work station
4. Disconnect the high-tension lead (spark plug wire) and remove the spark plug
5. Using a test plug, connect the high tension lead to the test plug and ground test plug to the cylinder head bolt (Figure 1)

FIGURE 1


Test Plug Grounded
To Cylinder Head
Alligator Clamp
Spark Tester Plug

JOB SHEET #2

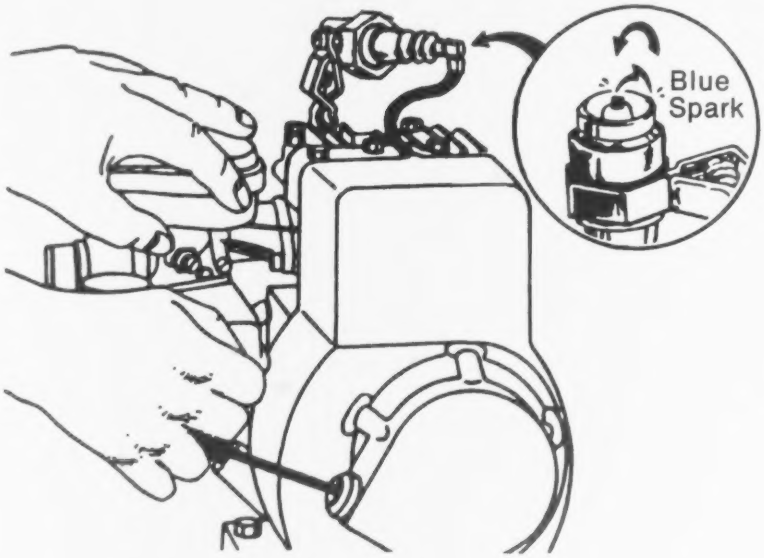
6. Crank the engine 2 to 3 times and observe the spark at the test plug (Figure 2)

    a. The spark should jump the gap and should be a bright blue color; this indicates the ignition system is functioning properly

    b. A spark that does not jump the gap from the shell to the center electrode indicates ignition problems

    c. A spark that jumps the gap but is yellow in color indicates poor ignition; the ignition system must be serviced

    FIGURE 2



7. Formulate problems and corrective measures

    a. Review list of probable causes

    b. Correct ignition problem

TROUBLESHOOTING
UNIT VII-D

JOB SHEET #3 — TROUBLESHOOT ENGINE COMPRESSION

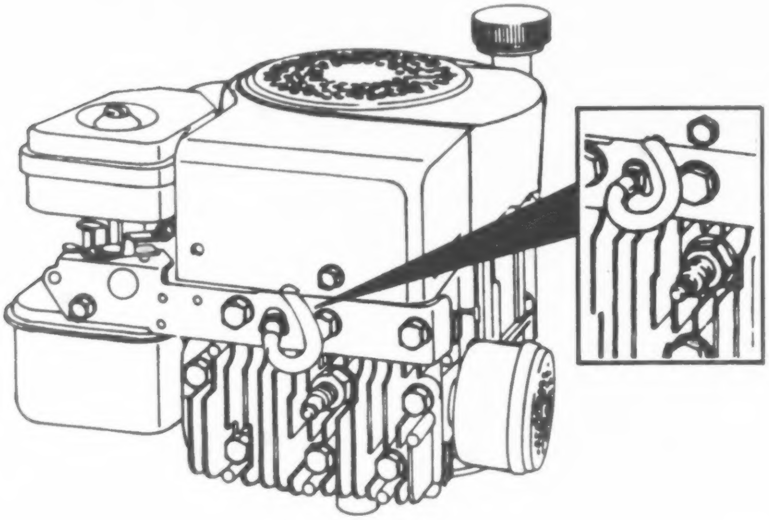
A. Tools and materials needed

1. Basic hand tool assortment
2. Compression gauge
3. Appropriate service manual
4. Safety glasses

B. Procedure

1. Wear proper safety equipment
2. Read operators' manual
3. Organize your work station
4. Remove the high-tension lead from the spark plug and secure (Figure 1)

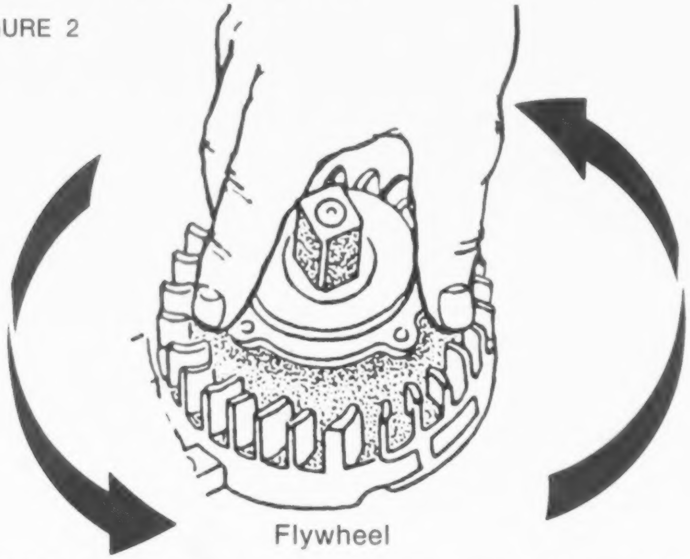
FIGURE 1



JOB SHEET #3

5. Manually spin the flywheel counterclockwise against the compression stroke; a sharp rebound indicates satisfactory compression; slight or no rebound indicates poor compression (Figure 2)

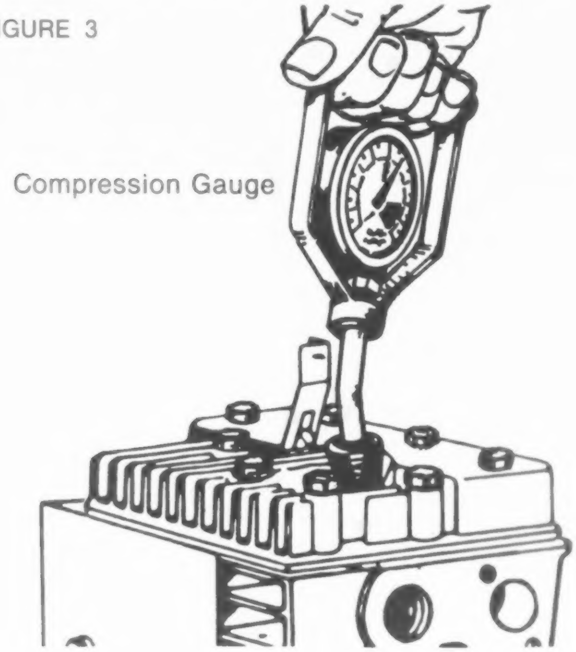
FIGURE 2



(NOTE: Briggs and Stratton engines are equipped with easy spin cam. Rotate the flywheel counterclockwise; a sharp rebound indicates good compression.)

6. Check the engine compression with a compression gauge (Figure 3)

FIGURE 3



JOB SHEET #3

7. Crank the engine over at least six times and read the compression gauge

8. Formulate problems and corrective measures

    a. Review list of probable causes

    b. Correct compression problems

TROUBLESHOOTING
UNIT VII-D

NAME ____________________

TEST

1. Define troubleshooting.

____

____

2. Select requirements for an engine to run by placing an "X" in the appropriate blanks.

_____a. Ignition

_____b. Speed

_____c. Compression

_____d. Carburetion

_____e. Centrifugal force

_____f. Pulley

3. Complete the following list of troubleshooting procedures by correctly filling in the blanks.

a. Know the engine

b. Ask the operator

c. ____

d. Operate the engine if possible

e. ____

f. Formulate a conclusion

g. ____

TEST

4. Select true statements concerning the importance of understanding troubleshooting procedures by placing an "X" in the appropriate blanks.

   _____a. Saves customer's money

   _____b. Insures a better repair job as the total system or engine is observed

   _____c. Insures better operating dependability

   _____d. Fewer employees are needed to operate shop

   _____e. Good service means continued business with present customers plus the drawing of new customers

   _____f. Makes employees more valuable since less work is returned

5. Solve the problems below using the small engine troubleshooting chart on the following page.

   (NOTE: There may be more than one possible cause of the problem. Choose one.)

   a. Engine is smoking excessively and overheating

   ____

   ____

   b. Engine will not start due to low compression

   ____

   ____

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

6. Demonstrate the ability to:

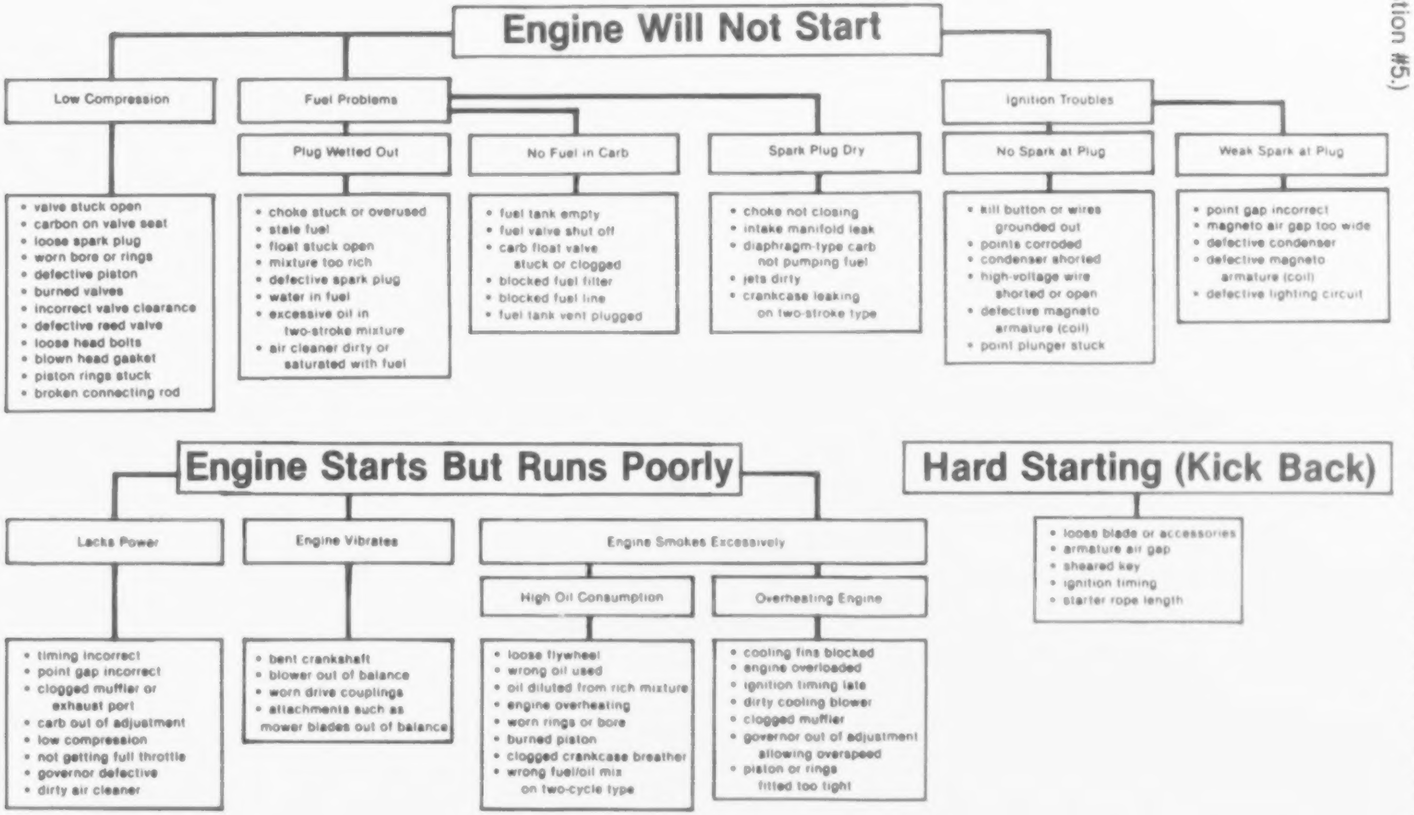
   a. Troubleshoot the fuel system (Job Sheet #1).

   b. Troubleshoot the ignition system (Job Sheet #2).

   c. Troubleshoot engine compression (Job Sheet #3).

TEST

(NOTE: The small engine troubleshooting chart below should be used to solve problems in test question #5.)



Engine Will Not Start

Low Compression

- valve stuck open
- carbon on valve seat
- loose spark plug
- worn bore or rings
- defective piston
- burned valves
- incorrect valve clearance
- defective reed valve
- loose head bolts
- blown head gasket
- piston rings stuck
- broken connecting rod

Fuel Problems

Plug Wetted Out

- choke stuck or overused
- stale fuel
- float stuck open
- mixture too rich
- defective spark plug
- water in fuel
- excessive oil in two-stroke mixture
- air cleaner dirty or saturated with fuel

No Fuel in Carb

- fuel tank empty
- fuel valve shut off
- carb float valve stuck or clogged
- blocked fuel filter
- blocked fuel line
- fuel tank vent plugged

Spark Plug Dry

- choke not closing
- intake manifold leak
- diaphragm-type carb not pumping fuel
- jets dirty
- crankcase leaking on two-stroke type

Ignition Troubles

No Spark at Plug

- kill button or wires grounded out
- points corroded
- condenser shorted
- high-voltage wire shorted or open
- defective magneto armature (coil)
- point plunger stuck

Weak Spark at Plug

- point gap incorrect
- magneto air gap too wide
- defective condenser
- defective magneto armature (coil)
- defective lighting circuit

Engine Starts But Runs Poorly

Lacks Power

- timing incorrect
- point gap incorrect
- clogged muffler or exhaust port
- carb out of adjustment
- low compression
- not getting full throttle
- governor defective
- dirty air cleaner

Engine Vibrates

- bent crankshaft
- blower out of balance
- worn drive couplings
- attachments such as mower blades out of balance

Engine Smokes Excessively

High Oil Consumption

- loose flywheel
- wrong oil used
- oil diluted from rich mixture
- engine overheating
- worn rings or bore
- burned piston
- clogged crankcase breather
- wrong fuel/oil mix on two-cycle type

Overheating Engine

- cooling fins blocked
- engine overloaded
- ignition timing late
- dirty cooling blower
- clogged muffler
- governor out of adjustment allowing overspeed
- piston or rings fitted too tight

Hard Starting (Kick Back)

- loose blade or accessories
- armature air gap
- sheared key
- ignition timing
- starter rope length

TROUBLESHOOTING
UNIT VII-D

ANSWERS TO TEST

1. Troubleshooting is the systematic diagnosis of engine malfunctions

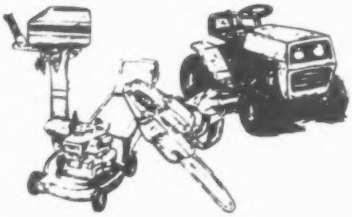
2. a,c,d

3. c. Inspect the engine
   e. List possible causes
   g. Test conclusion

4. a,b,c,e,f

5. Refer to small engine troubleshooting chart in unit

6. Performance skills evaluated according to standards identified by the instructor



Overhaul Four-Stroke Cycle Engine Unit VIII-D

UNIT OBJECTIVE

After completion of this unit, the student should be able to disassemble and reassemble a four-stroke cycle engine and inspect and service the cylinder, piston rings, connecting rod, crankshaft assembly, and valve train. Competencies will be demonstrated by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to the overhaul of a four-stroke cycle engine with their correct definitions.
2. List five causes of engine problems.
3. Identify the parts of the piston and connecting rod assembly.
4. Identify the parts of the crankshaft assembly.
5. Identify the parts of a multi-piece crankshaft.
6. Identify the parts of the valve train.
7. Demonstrate the ability to:
    a. Disassemble a four-stroke cycle engine (Job Sheet #1).
    b. Inspect and service a cylinder (Job Sheet #2).
    c. Inspect and service the piston, rings, and connecting rod (Job Sheet #3).

OBJECTIVE SHEET

d. Inspect and service a crankshaft and crankcase assembly (Job Sheet #4).

e. Inspect and service a valve assembly (Job Sheet #5).

f. Reassemble a four-stroke cycle engine (Job Sheet #6).

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VIII-D

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to supplement/reinforce information provided in this unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska]).

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets prior to the demonstration of the procedures.

H. Integrate the following activities throughout the teaching of this unit:

1. Provide examples of pistons and connecting rod assemblies, crankshaft assemblies, and valve trains.
2. Compare overhauls of four-stroke cycle and two-stroke cycle engines.
3. Demonstrate and discuss the procedures outlined in the job sheets.
4. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

SUGGESTED ACTIVITIES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

  1. TM 1 — Piston Assembly
  2. TM 2 — Connecting Rod Assembly
  3. TM 3 — Crankshaft Assembly
  4. TM 4 — Multi-Piece Crankshaft
  5. TM 5 — Valve Train

E. Job sheets

  1. Job Sheet #1 — Disassemble a Four-Stroke Cycle Engine
  2. Job Sheet #2 — Inspect and Service a Cylinder
  3. Job Sheet #3 — Inspect and Service the Piston, Rings, and Connecting Rod
  4. Job Sheet #4 — Inspect and Service a Crankshaft and Crankcase Assembly
  5. Job Sheet #5 — Inspect and Service a Valve Assembly
  6. Job Sheet #6 — Reassemble a Four-Stroke Cycle Engine

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. Herd, Amon. *Valves: Service and Repair.* Columbia, Missouri: Instructional Materials Laboratory, University of Missouri-Columbia.

B. *Twin Cylinder Repair Instructions.* Milwaukee, Wisconsin: Briggs and Stratton Corporation, 1980.

C. Comprehensive Small Engine Repair. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

SUGGESTED ACTIVITIES

D. *Harley-Davidson Service Manual: Sportster* XL/XLH/XLCX, 1970-1973.Harley Davidson Motor Co., Inc., 1972.

E. *Small Engines, Volume 2*. Athens, Georgia: American Association of Vocational Instructional Materials, 1974.

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VIII-D

INFORMATION SHEET

I. **Terms and definitions**

A. Overhaul — To restore to manufacturer's specifications

B. Abrasion — Wearing or rubbing away

C. Anti-friction bearing — Bearing constructed with balls or rollers between journal and bearing surface to provide rolling instead of sliding friction

D. Babbit — Alloy of tin, copper, lead, silver, and antimony having good anti-friction properties; used as a facing for bearings

E. Backlash — Clearance or "play" between two parts

Example: Meshed gears

F. Blow-by — Leakage or loss of pressure

(NOTE: This is often used with reference to leakage of compression past piston ring between piston and cylinder.)

G. Break in — Process of wearing into a desirable fit new or reconditioned parts

H. Bushing — Removable sleeve used as a bearing

I. Camshaft — Shaft containing lobes or cams which operate engine valves

J. Carbon — Common nonmetallic element which forms in combustion chamber of an engine during burning of fuel and lubricating oil

K. Clearance — Space allowed between two parts

Example: Space between a journal and a bearing

L. Crankshaft counterbalance — Series of weights attached to or forged integrally with the crankshaft, placed so as to offset the reciprocating weight of each piston and rod assembly

M. Floating piston pin — Piston pin which is not locked in the connecting rod or the piston, but is free to turn or oscillate in both the connecting rod and the piston

N. Gasket — Substance placed between two metal surfaces to act as a seal

INFORMATION SHEET

O. Hone — Abrasive tool for deglazing and correcting irregularities or differences in diameter in the cylinder

Example: Engine cylinder

P. Interference angle — Difference in angle between mating surfaces of a valve and a valve seat

Q. Journal — Part of a shaft or crank which rotates inside a bearing

R. Oil pumping — Term used to describe an engine which is using an excessive amount of lubricating oil

S. Piston slap — Rocking of loose fitting piston in a cylinder, making a hollow bell-like sound

T. Press fit — Known as a force fit or drive fit

(NOTE: This fit is accomplished by forcing a shaft into a hole slightly smaller than the shaft.)

U. Running fit — Sufficient clearance has been allowed between the shaft and journal to allow free running without overheating

V. Seize — One surface adhering to another because of heat and pressure

Example: A piston will seize in a cylinder because of lack of lubrication or overexpansion due to excessive heat

W. Shrink fit — Exceptionally tight fit achieved by heating and/or cooling of parts

(NOTE: The outer part is heated above its normal operating temperature or the inner part chilled below its normal operating temperature and assembled in this condition.)

X. Valve lapping — Process of mating the valve seat and valve face

(NOTE: This is performed with the aid of an abrasive.)

Y. Valve grinding — Process of refacing the valve and seat to manufacturer's specifications

Z. Valve face — Angle surface of valve which mates with the seat to seal the chamber

AA. Valve head — Top of the large diametered valve end

BB. Valve margin — Space between valve face and head

INFORMATION SHEET

CC. Valve stem — Long portion of valve which rests within the valve guide

DD. Valve seat — Angle surface in engine block or head which provides mating surface for valve face

EE. Valve clearance — Distance between valve stem and tappet at lowest tappet position

II. **Causes of engine problems**

A. Allowing dirt to get into the engine

B. Failure to check crankcase oil level often enough and letting engine run low on oil

C. Overloading the engine so that it works too hard

D. Running the engine too fast

E. Failure to properly store the engine during the off season

III. **Parts of piston and connecting rod assembly** (Transparencies 1 and 2)

A. Land

B. Piston head

C. Piston pin (wrist pin)

D. Skirt

E. Pin hole

F. Oil ring groove

G. Compression and scraper ring groove

H. Ring side clearance

I. Thrust face clearance

J. Retaining ring

K. Connecting rod

L. Connecting rod bearing cap

M. Connecting rod bolts, washers, and nuts

INFORMATION SHEET

IV. **Parts of crankshaft assembly** (Transparency 3)

   A. Main bearing journals

   B. Crankpin

   (NOTE: This is the connecting rod bearing journal.)

   C. Counterweights

V. **Parts of a multi-piece crankshaft** (Transparency 4)

   A. Threads and keyway

   B. Mag journal

   C. Crankpin

   D. Gear teeth and keyway

   E. P.T.O. journal

   F. Keyway

VI. **Parts of the valve train** (Transparency 5)

   A. Margin

   B. Seat

   C. Stem

   D. Face

   E. Retainer

   F. Adjusting nut

   G. Tappet guide

   H. Cam

   I. Head

   J. Valve guide

   K. Valve spring

   L. Clearance

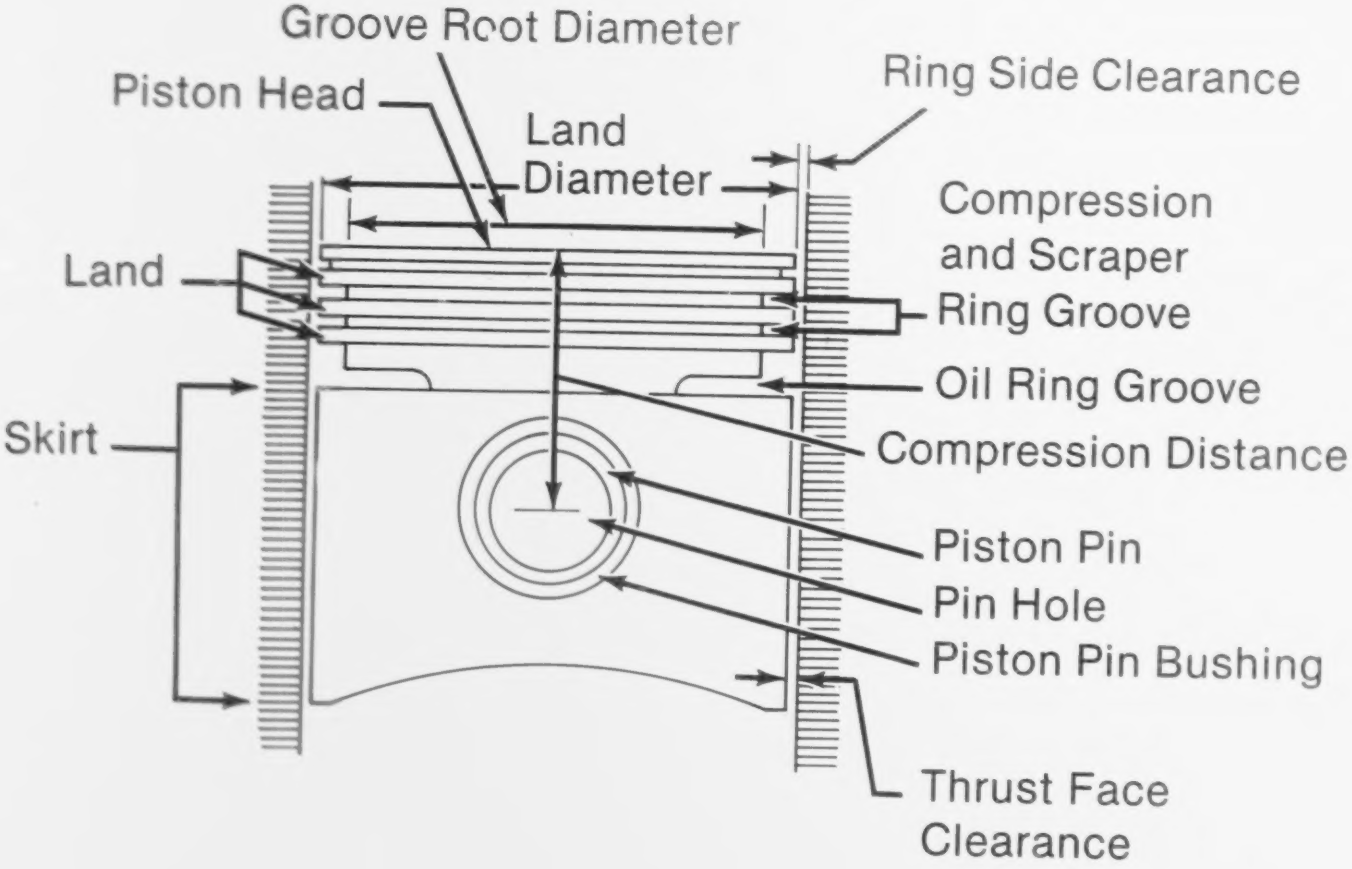
INFORMATION SHEET

M. Locknut

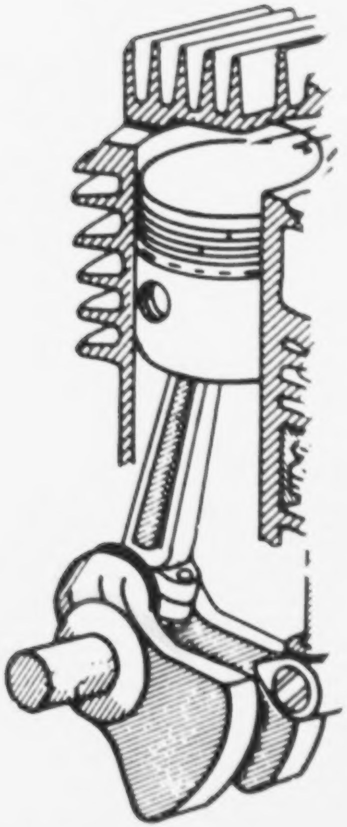
N. Tappet

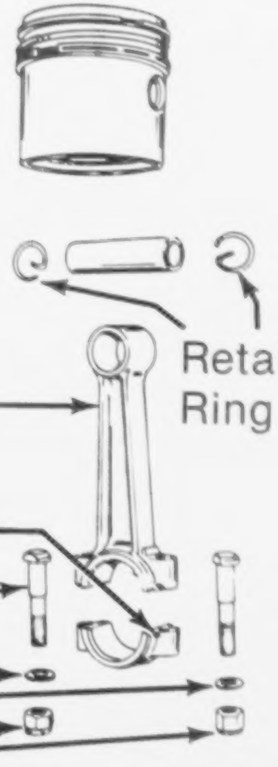
O. Shaft

Piston Assembly


Groove Root Diameter
Piston Head
Land Diameter
Ring Side Clearance
Compression and Scraper Ring Groove
Land
Oil Ring Groove
Skirt
Compression Distance
Piston Pin
Pin Hole
Piston Pin Bushing
Thrust Face Clearance

Connecting Rod Assembly





Retaining Ring

Connecting Rod

Bearing Cap

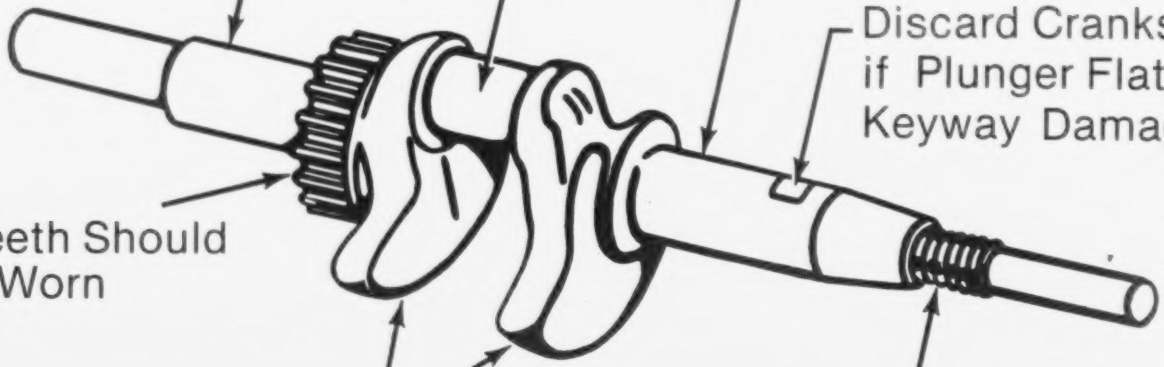
Connecting-Rod Bolt

Washer

Self-Locking Nut

Crankshaft Assembly

Discard Crankshaft if Small or Out of Round



Journal Magneto End

Journal Crankpin

Journal P.T.O. End

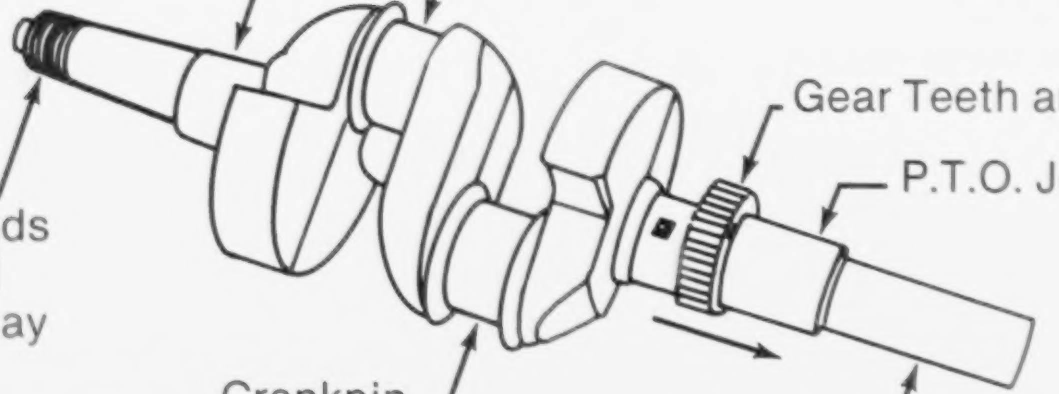
Discard Crankshaft if Plunger Flat or Keyway Damaged

Gear Teeth Should Not Be Worn

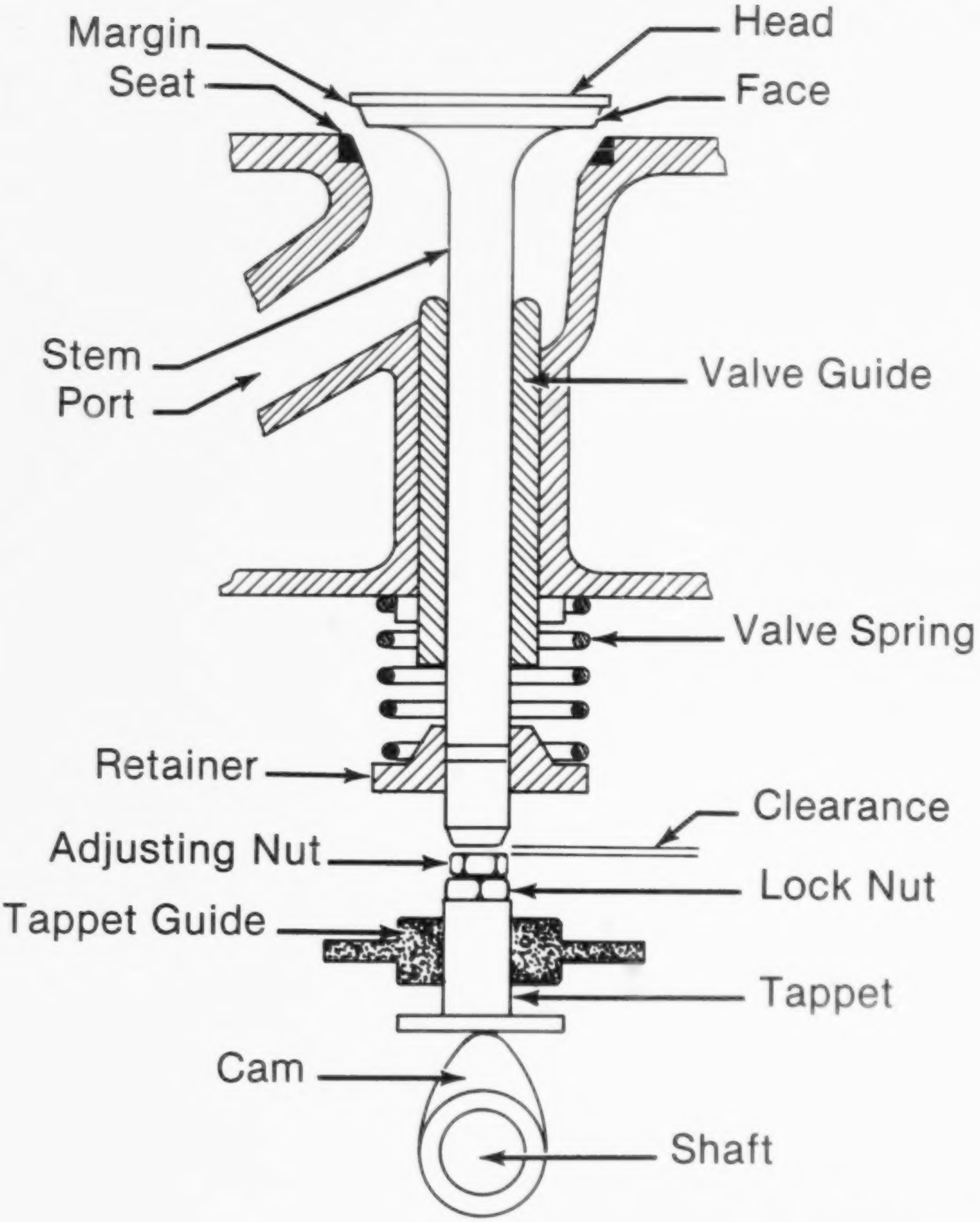
Counterweights

Threads Should Not Be Damaged

Multi-Piece Crankshaft


Mag. Journal
Crankpin
Gear Teeth and Keyway
P.T.O. Journal
Threads and Keyway
Crankpin
Keyway

Valve Train


Margin
Head
Seat
Face
Stem
Port
Valve Guide
Valve Spring
Retainer
Clearance
Adjusting Nut
Lock Nut
Tappet Guide
Tappet
Cam
Shaft

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VIII-D

JOB SHEET #1 — DISASSEMBLE A FOUR-STROKE CYCLE ENGINE

A. Tools and materials needed

1. Hand tool assortment
2. Flywheel wrench
3. Flywheel holder
4. Flywheel puller
5. Valve spring compressor
6. Engine stand
7. Shop towels
8. Cleaning solvent
9. Safety glasses

B. Procedure

1. Disconnect spark plug cable, battery connections, and remove spark plug
2. Drain oil from crankcase
3. Disconnect all belts, chains, remote throttle control linkage, and exhaust system if attached to implement or vehicle
4. Remove engine from implement or vehicle

   (NOTE: If remote fuel tank is used, disconnect fuel lines from engine.)

5. Mount engine on suitable stand

   (NOTE: Some smaller engines are easier to disassemble on a work bench.)

6. Remove starter unit
7. Remove air cleaner and its mounting bracket
8. Remove exhaust pipe and muffler
9. Remove carburetor and intake manifold

   (NOTE: Be sure to note throttle and choke connections; it might help to sketch the linkage.)

JOB SHEET #1

10. Remove air shroud, blower housing baffles, and fuel tank

    (CAUTION: Position tank so fuel will not leak out.)

11. Remove the flywheel

    (NOTE: Always use the right puller.)

12. Remove all magneto components

    (NOTE: On Tecumseh engines, mark stator plate with chisel or punch before removing.)

13. Clean all outside surfaces of the engine using an approved solvent

    (CAUTION: Never use gas or solvents that burn easily nor those which may be harmful to humans.)

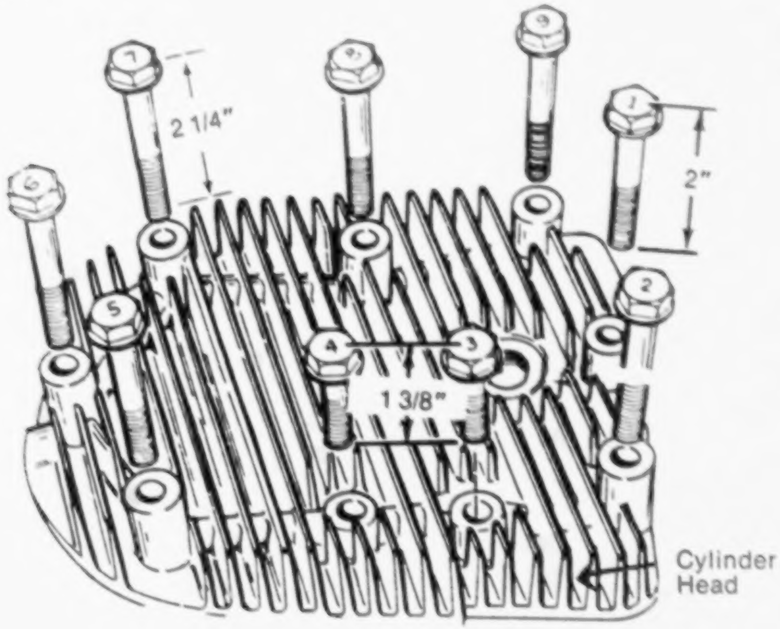
    (NOTE: As parts are cleaned and dried lay them out in an organized pattern on the clean workbench.)

14. Remove the cylinder head

    (NOTE: On engines with overhead camshafts refer to appropriate service manual for exact procedures.)

15. Mark bolts so different length bolts will be returned to the proper location (Figure 1)

FIGURE 1

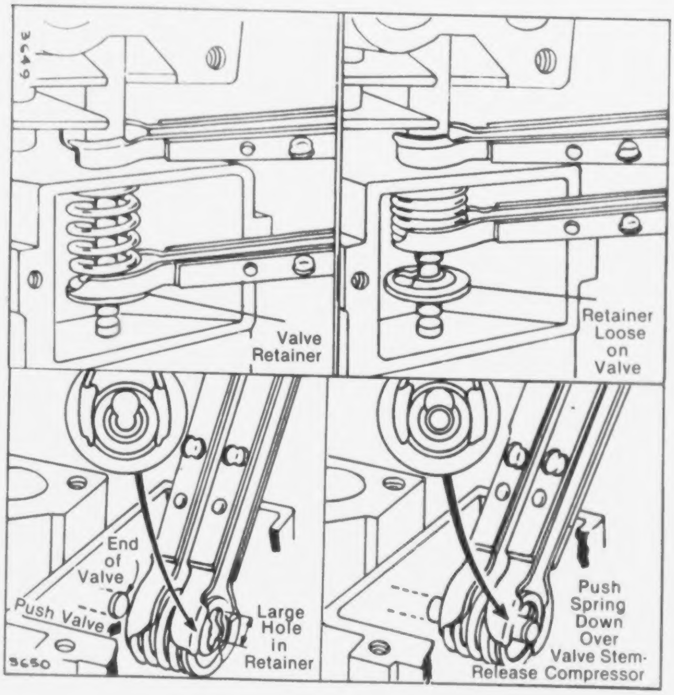


JOB SHEET #1

16. Remove valve cover

17. Install valve spring compressor (Figure 2)

FIGURE 2


3649
Valve Retainer
Retainer Loose on Valve
End of Valve
Push Valve
Large Hole in Retainer
3650
Push Spring Down Over Valve Stem-Release Compressor

18. Compress valve spring

19. Remove spring keepers and collars

20. Remove tension on valve spring

21. Remove spring compressor

22. Remove valve

    (NOTE: Be sure and check for roughness at valve lock groove to prevent guide damage during removal.)

23. Remove spring

    (NOTE: Mark springs as exhaust or intake for reassembly.)

24. Repeat steps "Q" through "W" for other valve(s)

JOB SHEET #1

25. Remove piston assembly

    (NOTE: Refer to appropriate service manuals for exact procedures on engines with removable cylinders.)

    a. Rotate crankshaft until piston is at bottom of cylinder

    b. Remove oil sump

       (CAUTION: Be sure crankshaft is clean before sump is removed.)

    c. Remove oil slinger or pump, camshaft, and tappets

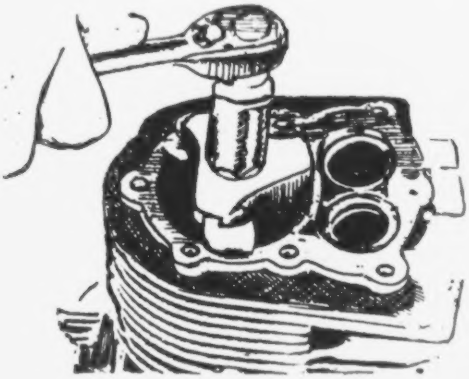
       (NOTE: Mark tappets for replacement.)

    d. Feel upper cylinder with finger to check for a ridge

    e. Remove ridge with ridge cutter (Figure 3)

       (NOTE: Refer to ridge cutter installation and cutting procedures.)

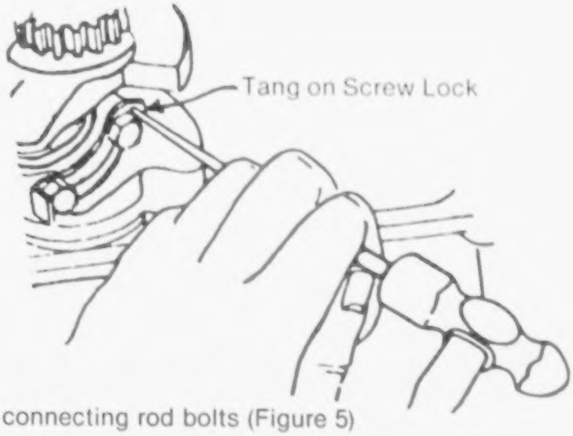
       FIGURE 3



JOB SHEET #1

f. Bend tang away from connecting rod bolts (Figure 4)

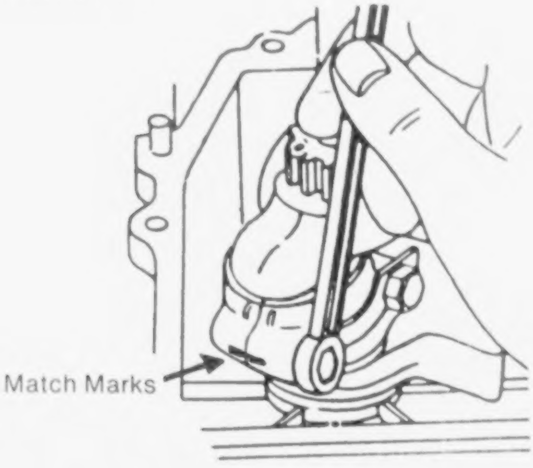
FIGURE 4


Tang on Screw Lock

g. Remove connecting rod bolts (Figure 5)

(NOTE: Notice location of marks on bearing cap and rod so they can be returned to correct location.)

FIGURE 5

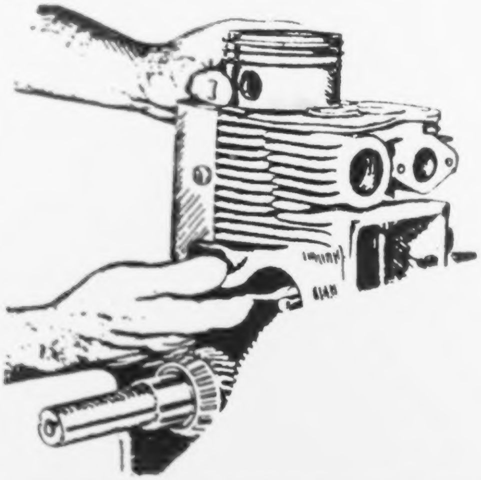

Match Marks

JOB SHEET #1

h. Remove piston and rod (Figure 6)

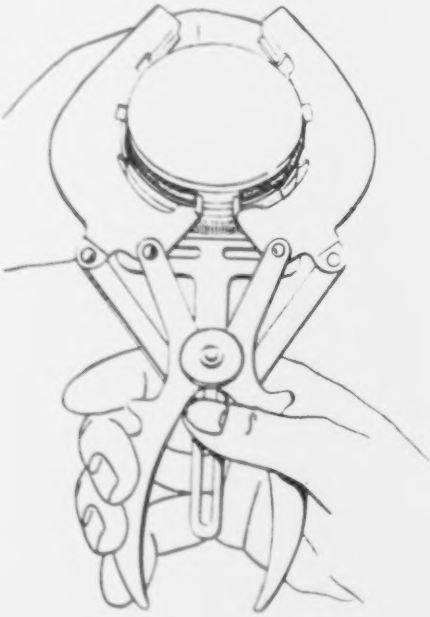
(NOTE: Scribe across piston and block so piston can be returned in its original direction.)

FIGURE 6



26. Remove rings from piston using the correct ring expander (Figure 7)

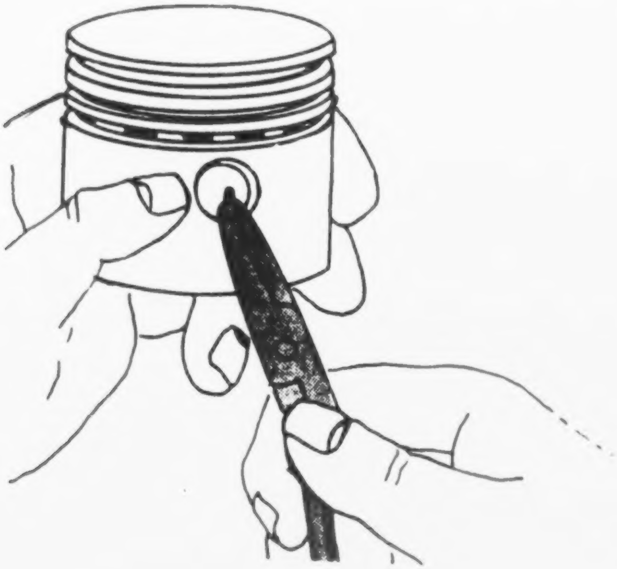
FIGURE 7



JOB SHEET #1

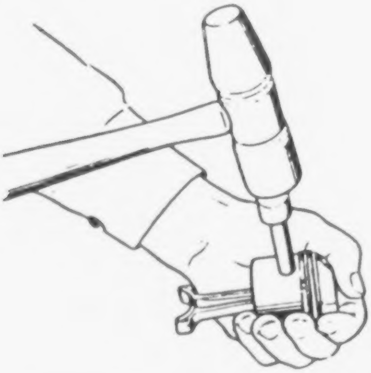
27. Remove piston pin locks (Figure 8)

FIGURE 8



28. Remove piston pin (Figure 9)

FIGURE 9



29. Remove crankshaft

    a. Remove crankshaft retainers if any are used

JOB SHEET #1

b. Remove crankshaft from block and bearing plate (Figures 10 and 11)

FIGURE 10

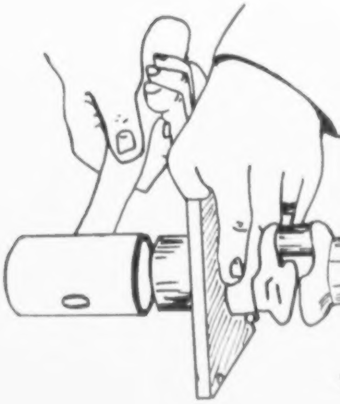
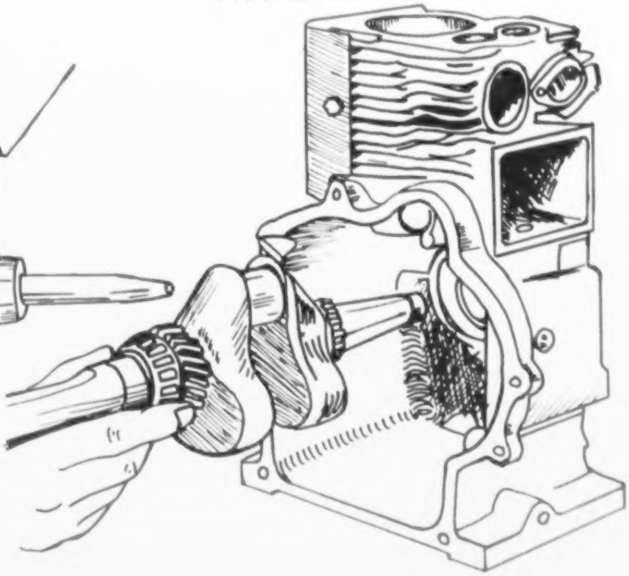


FIGURE 11



(NOTE: A gentle pull on engines with tapered roller bearings will usually work. On engines with sleeve inserts or cast in bearings, gentle taps with a soft mallet are often required.)

30. Clean all parts and dry for inspection and measurement

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VIII-D

JOB SHEET #2 — INSPECT AND SERVICE A CYLINDER

A. Tools and materials needed

1. Measuring instruments
2. Deglazing tool
3. Portable drill
4. Cylinder vise support
5. Light oil 5-10 weight
6. Shop towels
7. Hand tool assortment
8. Hone
9. Safety glasses

B. Procedure

1. Inspect

    a. Examine for cracks, stripped threads, broken fins, and scored and damaged cylinder walls

    (NOTE: Any of these may require replacement of the cylinder.)

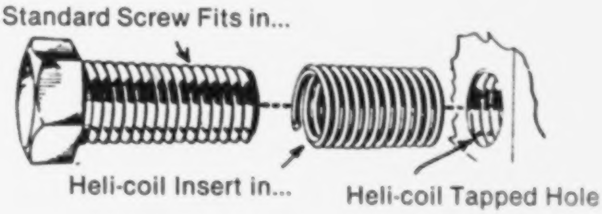
    b. Repair any stripped threads using a Heli-coil

    1) Drill out worn thread

    2) Tap hole with Heli-coil tap

    3) Install Heli-coil insert to bring hole back to original thread (Figure 1)

FIGURE 1

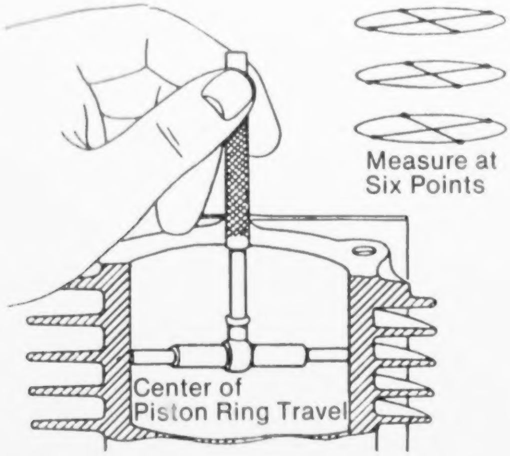


JOB SHEET #2

2. Measure ring travels

   a. Take measurements at top, center, and bottom of ring travels both parallel and at right angles to the crankshaft (Figure 2)

FIGURE 2



   b. Check to see if measurements are within manufacturer's specifications

3. Deglaze cylinder if it falls within manufacturer's specified tolerances

   (NOTE: Refer to appropriate service manual for exact deglazing procedures.)

   a. Clean cylinder with hot soapy water

      (NOTE: Do not use gasoline, kerosene, or solvents for this cleaning job.)

   b. Dry cylinder

4. Bore cylinders

   (NOTE: Check manufacturer's specifications for equipment needed. If engine does not meet manufacturer's specifications for standard ring replacement, it should be bored or honed.)

   a. Determine cylinder wall type

      (NOTE: Some cylinders cannot be rebored. Chrome plated aluminum cylinders, for instance, must be discarded if worn or damaged.)

JOB SHEET #2

b. Hone boring to oversize

(NOTE: Boring is done in .010 increments. If first .010 leaves nicks or scrapes unrepaired, go to .020 over standard.)

1) Install cylinder in vise or cylinder support

2) Insert hone into cylinder

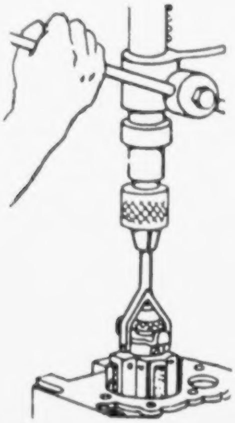
(NOTE: Be sure and use correct stone.)

3) Start drill or drill press

4) Raise and lower hone in cylinder while it rotates (Figure 3)

(NOTE: Do not go below cylinder 1/4" or above 1/4".)

FIGURE 3



5) Stop periodically to measure progress

6) Stop boring when you are within .002 in. of desired diameter

7) Change to finishing stones and finish honing to crosshatch pattern

8) Clean cylinders

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VIII-D

JOB SHEET #3 — INSPECT AND SERVICE THE PISTON, RINGS, AND CONNECTING ROD

A. Tools and materials needed

1. Outside micrometer
2. Telescoping gauge
3. Ring groove cleaner
4. Feeler gauges
5. Ring expander
6. Manufacturer's engine manual
7. Hand tool assortment
8. Safety glasses

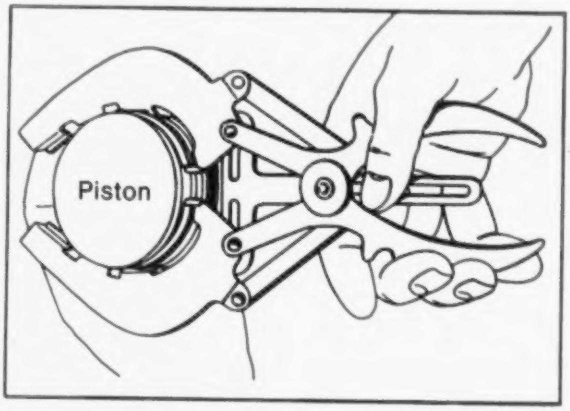
B. Procedure

1. Check piston visually for scoring wear spots and deformities

   (NOTE: Discard the piston and replace with a new one if you feel it has damage that will affect engine performance.)

2. Secure piston in vise
3. Remove rings using ring expander (Figure 1)

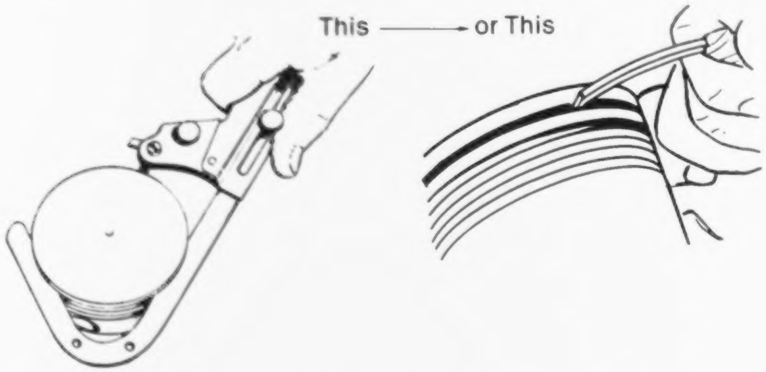
   FIGURE 1



JOB SHEET #3

4. Clean carbon from ring grooves with special cleaner (Figure 2)

FIGURE 2

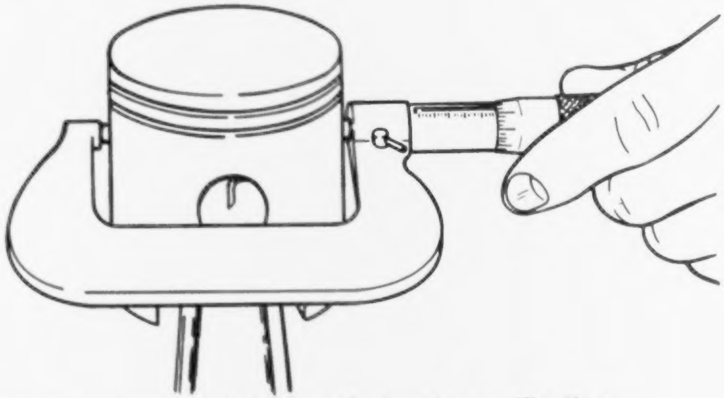


(NOTE: Do not alter the groove size. Do not remove metal from grooves. Do not use caustic solvent. Do not use a wire brush or buffer.)

5. Take piston measurement below ring grooves (Figure 3)

(NOTE: Take four measurements, two at right angle to pin opening and two parallel.)

FIGURE 3



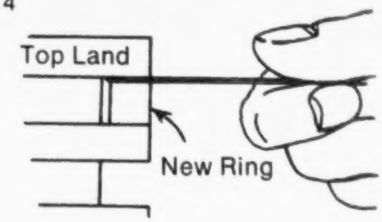
6. Compare measurements to manufacturer's specifications

(NOTE: Discard piston if it does not fall within manufacturer's specifications.)

JOB SHEET #3

7. Check for ring groove wear
   a. Install new ring using ring expander
   b. Insert feeler gauge between ring and groove (Figure 4)

FIGURE 4



   c. Compare with the manufacturer's specifications

(NOTE: Discard piston if measurements do not fall within manufacturer's tolerances.)

   d. Repeat for remaining ring grooves

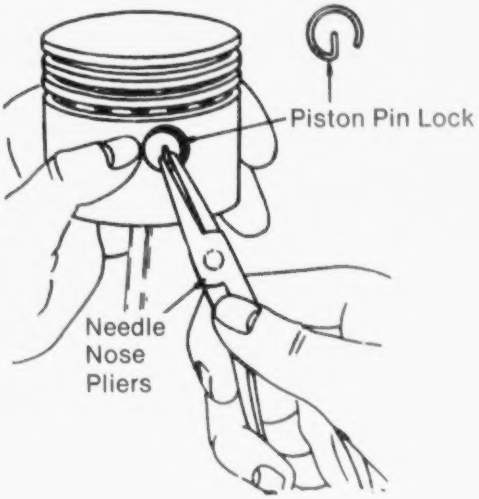
(NOTE: On some multi-cylinder engines the manufacturers recommend piston balancing. Refer to appropriate service manual.)

JOB SHEET #3

8. Service and inspect pin and connecting rod

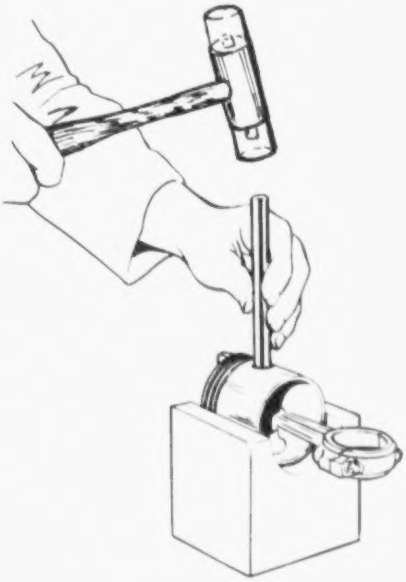
    a. Remove pin retainers (Figure 5)

    FIGURE 5


Piston Pin Lock
Needle
Nose
Pliers

    b. Drive out piston pin with soft hammer and dowel (Figure 6)

    FIGURE 6



JOB SHEET #3

c. Measure pin diameter using micrometer

d. Measure piston boss with small hole gauge

e. Measure hole gauge with micrometer

f. Subtract pin measurement from boss measurement

g. Compare to manufacturer's specifications

(NOTE: Some manufacturers recommend replacement if tolerances are not within specifications; others recommend boring piston bosses to oversize and using a larger pin. Some rods use replaceable bearings. Refer to appropriate service manual for exact procedures.)

h. Check rod for straightness

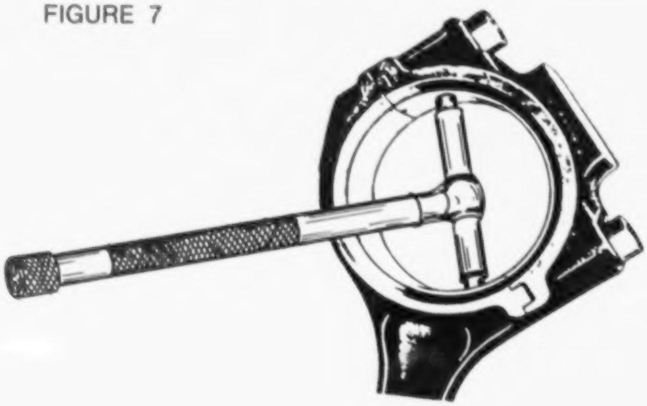
(NOTE: Big and small bearing holes must be parallel. Do not straighten; replace as necessary. Some multi-cylinder engines require rod balancing. Refer to appropriate service manual.)

i. Connect rod cap to connecting rod

(NOTE: Be sure alignment marks on cap and rod are mated before tightening cap screws. Refer to appropriate service manual for torque.)

j. Measure inside diameter of crankpin opening in two places 180° apart (Figure 7)

FIGURE 7



k. Compare reading to manufacturer's specification

(NOTE: If out-of-roundness is found in your readings, discard rod and get a new one to replace it. On models with bearing inserts put in new bearings if manufacturer's specifications are not met or out-of-roundness is found.)

l. Use of plastigauge is quicker and more accurate

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VIII-D

JOB SHEET #4 — INSPECT AND SERVICE A CRANKSHAFT AND CRANKCASE ASSEMBLY

A. Tools and materials needed

1. Telescoping gauge
2. Outside micrometer
3. Seal removal tools
4. Seal installation tools
5. Bearing pullers
6. Bearing installation tools
7. Hand tool assortment
8. Safety glasses
9. Reject gauges

B. Procedure

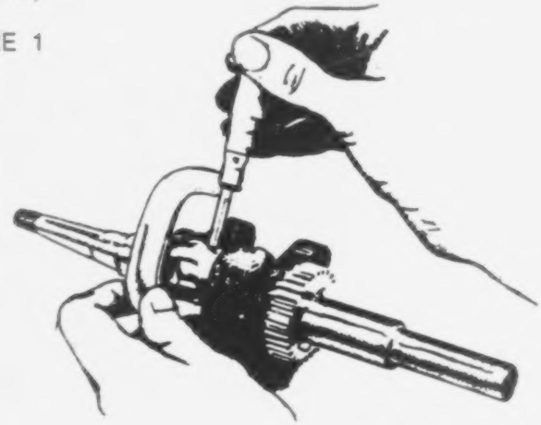
1. Inspect crankshaft for scoring, straightness, damaged keyway, damaged breaker flat, battered threads or worn timing gear teeth
2. Check crankshaft for run out

JOB SHEET #4

3. Using an outside micrometer check main bearing journals and crankpin journal for out-of-roundness and taper (Figure 1)

   (NOTE: Check two or three places up and down the journal as well as two places around it.)

   FIGURE 1



4. Compare measurements to manufacturer's specifications

   (NOTE: On some engines the crankshaft is separable and journals can be replaced. Some expensive crankshafts can be reground to a standard undersize. Most crankshafts should be replaced if they do not fall within specifications.)

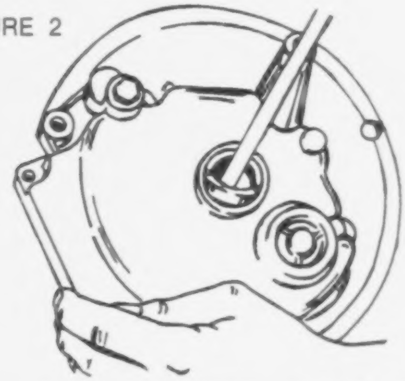
5. Check and service main bearings and seals

   a. Check seals

      1) Visually check for lip deterioration or wear

      2) Remove damaged seals (Figure 2)

      FIGURE 2

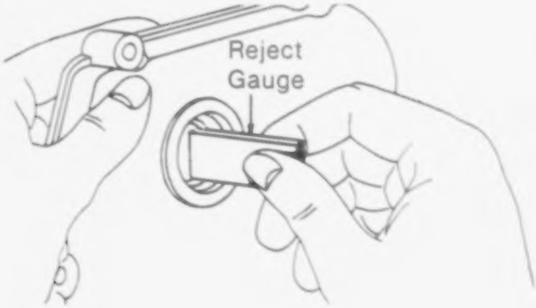


(NOTE: Special seal removal tools are available.)

JOB SHEET #4

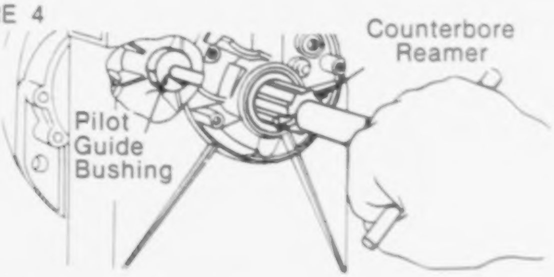
b. Check bearing for wear using a no go gauge (Figure 3)

FIGURE 3


Reject
Gauge

c. Place pilot guide bushing in the sump bearing with flange of pilot guide bushing toward inside of the sump (Figure 4)

FIGURE 4


Counterbore
Reamer
Pilot
Guide
Bushing

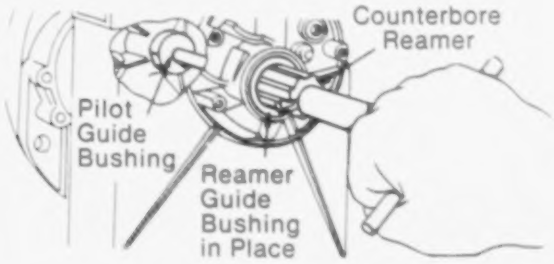
d. Assemble sump on cylinder

(NOTE: Be careful that the pilot guide bushing does not fall out of place.)

e. Place reamer guide bushing into the oil seal recess in the cylinder

f. Place counterbore reamer in pilot and insert into cylinder until the tip of the pilot enters the pilot guide bushing in the sump (Figure 5)

FIGURE 5

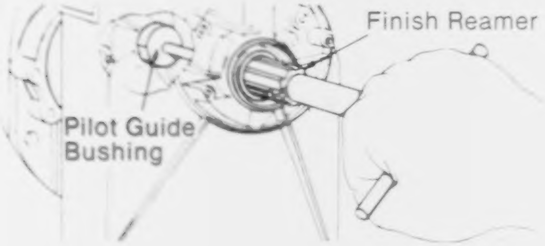

Counterbore
Reamer
Pilot
Guide
Bushing
Reamer
Guide
Bushing
in Place

JOB SHEET #4

g. Turn reamer clockwise with even steady pressure until it is completely through the bearing (Figure 6)

(NOTE: Lubricate reamer with kerosene or stoddard solvent.)

FIGURE 6



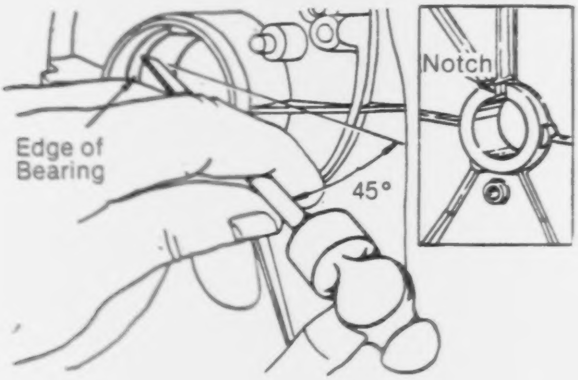
h. Remove sump and pull reamer out without backing it through the bearing

(NOTE: Clean out reaming chips and remove reamer guide bushing.)

i. Place new bushing, with notch toward cylinder and in line with notch on inside of cylinder against reamed out bearing (Figure 7)

(NOTE: At a point opposite to the split in the bushing, using a chisel and hammer, make a notch in the reamed out cylinder bearing at a 45° angle.)

FIGURE 7

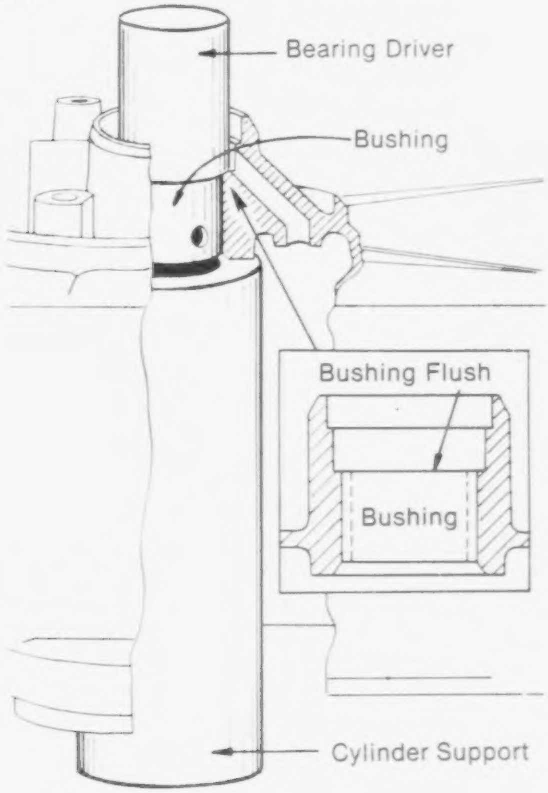


JOB SHEET #4

j. Press in the new bushing, making sure to align the oil notches (Figure 8)

(NOTE: Using driver and support drive bushing, flush with the end of the reamed out cylinder hub.)

FIGURE 8


Bearing Driver
Bushing
Bushing Flush
Bushing
Cylinder Support

k. Using a chisel, drive a portion of the bushing into the notch previously made in the cylinder

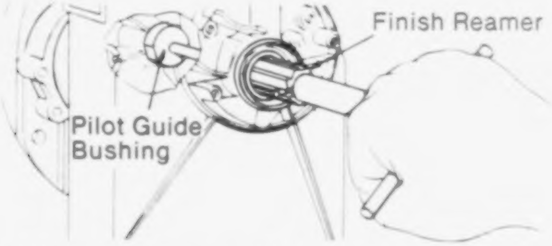
(NOTE: This is called staking and is done to prevent the bushing from turning.)

l. Reassemble sump to cylinder with pilot guide bushing in the sump bearing.

JOB SHEET #4

m. Place finish reamer on pilot and insert the pilot into the cylinder bearing until the tip of the pilot enters the pilot guide bushing in the sump bearing (Figure 9)

FIGURE 9



(NOTE: Lubricate the reamer with kerosene, fuel oil or stoddard solvent.)

n. Remove sump and pull reamer out without backing it through the bearing; remove pilot guide bushing and clean out all remaining chips

o. On most cylinders, the breaker point plunger hole enters the reamed out main bearing and a burr is formed by the countedbore reaming operation; the burr can be removed by using a special finish reamer

(NOTE: Make sure you have cleaned out all remaining chips.)

p. Install new seal

q. Return tools and equipment to their proper places and clean work area

(NOTE: Replacing P.T.O. bearing can be done in a similar manner.)

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VIII-D

JOB SHEET #5 — INSPECT AND SERVICE A VALVE ASSEMBLY

A. Tools and materials needed

1. Valve seat grinding equipment
2. Valve face grinding equipment
3. Outside micrometer
4. Telescoping gauge
5. Valve spring tension tester
6. Combination square
7. Valve seat removal tools
8. Valve seat driver
9. Valve guide removal tools
10. Valve guide reamers
11. Hand tool assortment
12. Mallet
13. Square or scale
14. Surface plate
15. Safety glasses
16. Appropriate service manual

JOB SHEET #5

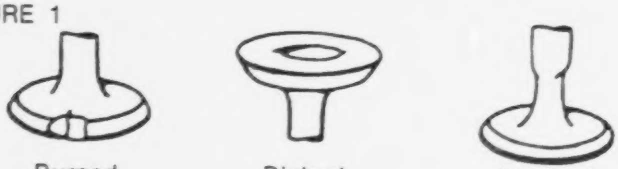
B. Procedure

1. Inspect valves

a. Visually check valve for unusual or uneven wear, burned spots, pits, cracks, bent or burnt stems, and other damage (Figure 1)

(NOTE: Discard the valve if pits or cracks are too deep to dress off during regrinding or if stem is bent.)

FIGURE 1

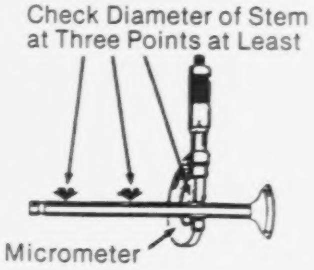


Burned Dished Necked

b. Measure the valve stem with a micrometer (Figure 2)

(NOTE: Discard the valve if it does not fall within manufacturer's specifications.)

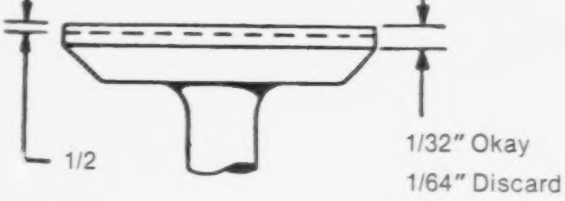
FIGURE 2


Check Diameter of Stem at Three Points at Least
Micrometer

c. Measure valve margin (Figure 3)

(NOTE: Generally if margin is less than 1/64", valve is discarded; consult appropriate service manual for exact measurements.)

FIGURE 3


1/2
1/32" Okay
1/64" Discard

JOB SHEET #5

2. Repair valves

   a. Determine correct angle and face width from appropriate service manual

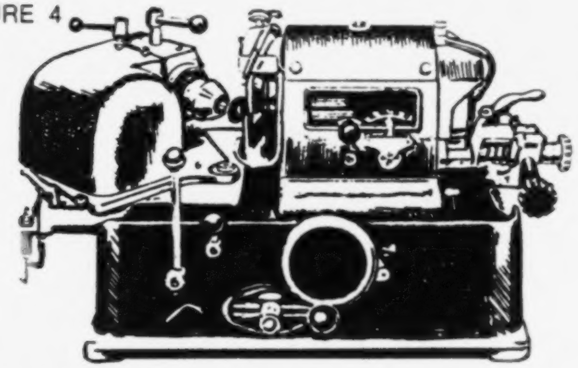
   b. Chuck valve in grinder

   (NOTE: Refer to grinder directions for proper procedure. Dress grinding wheel if necessary.

   c. Set grinder angle (Figure 4)

   (NOTE: Consult grinder set up manual.)

   FIGURE 4



   d. Grind valve

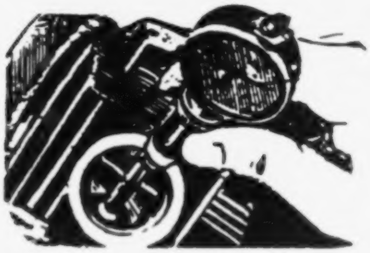
   e. Measure margin and seating surface

   (NOTE: Discard valve if suitable margin does not exist.)

3. Inspect valve guides

   a. Measure inside diameter with dial indicator or telescoping gauge and micrometer or valve guide reject gauge (Figure 5)

   FIGURE 5



JOB SHEET #5

b. Compare to manufacturer's specifications

(NOTE: If measurement does not fall within manufacturer's specifications, repair or replace.)

4. Repair valve guides

(NOTE: There are two basic types of guides, those bored directly into the block and those using inserts.)

a. Replace insert type valve guides

1) Remove worn guide

(NOTE: This may require a special tool; consult appropriate service manual.)

2) Install new guide

3) Ream to fit valve stem

(NOTE: Be sure clearances between stem and guide fall within manufacturer's recommended tolerances.)

b. Repair guide without bushing inserts

(NOTE: Many aluminum block engines have drilled guides with no inserts.)

1) Ream to standard oversize

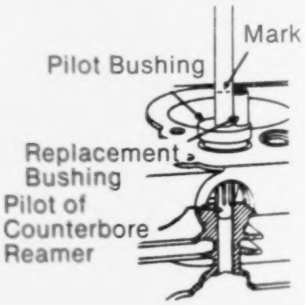
a) Select appropriate reamer

(NOTE: Reamer should oversize guide to appropriate size for oversized stems with manufacturer's recommended clearances.)

JOB SHEET #5

b) Install reamer (Figure 6)

FIGURE 6


Mark
Pilot Bushing
Replacement Bushing
Pilot of Counterbore Reamer

c) Rotate reamer while applying light downward pressure

d) Ream entire length of guide

e) Measure reamed guide with telescoping gauge and micrometer or dial indicator

2) Ream for guide insert

a) Select appropriate reamer

(NOTE: Your reamer needs to be large enough to allow for an insert to be pressed into the bore. The bore should be approximately .001 in. smaller than the insert.)

b) Ream guide

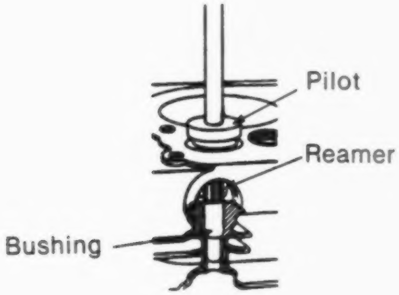
c) Install guide insert

JOB SHEET #5

d) Ream to standard size (Figure 7)

(NOTE: Reamer used here should put new insert to standard size with recommended clearances.)

FIGURE 7



5. Inspect valve seats

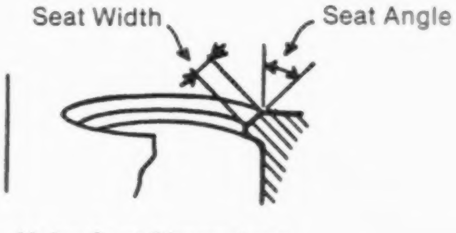
(NOTE: Check to see if valve seat is machined into the head or if it is an insert.)

a. Visually check valve seats for cracking and pitting

b. Check seat width and angle (Figure 8)

(NOTE: Depth of valve seat and its width can tell you about the number of times it has been refaced.)

FIGURE 8



Valve Seat Dimensions

JOB SHEET #5

6. Repair or replace valve seats

   a. Reface valve seats

      1) Select appropriate refacing tools (Figures 9 and 10)

         (NOTE: Drill motors and carborandum wheels or special cutters of the appropriate size will work.)

FIGURE 9

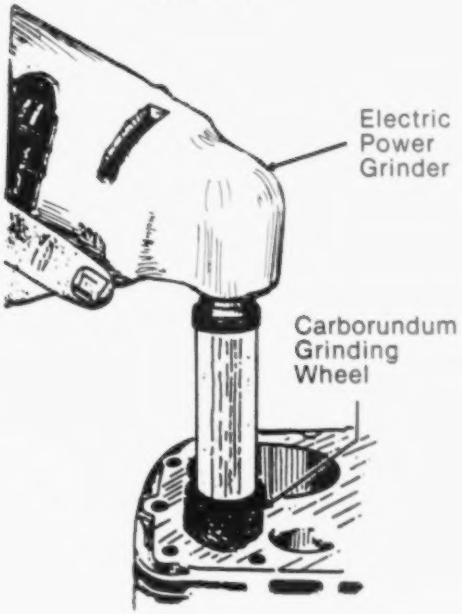
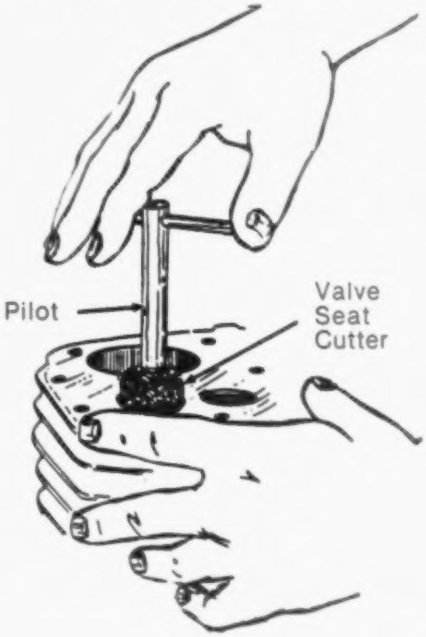

Electric
Power
Grinder
Carborundum
Grinding
Wheel

FIGURE 10


Pilot
Valve
Seat
Cutter

      2) Install pilot in guide

         (NOTE: Guides should have been inspected or reconditioned to guarantee straightness.)

      3) Install refacing tool

      4) Using light pressure, start tool rotating in clockwise direction only

      5) Cut all oxidation away

      6) Check seat width

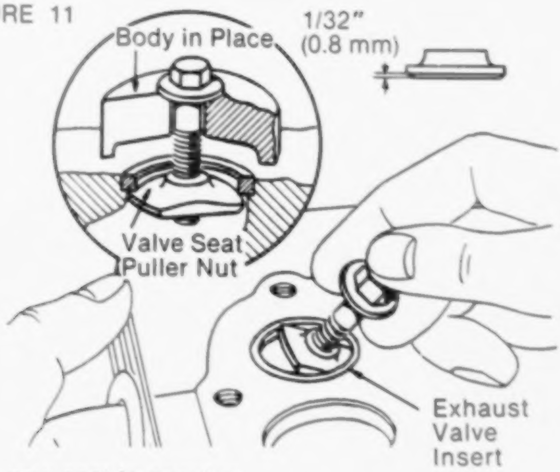
         (NOTE: If width is over ⅛", narrow it down with a 15° to 30° wheel at the top and a 60° to 75° wheel at the bottom.)

JOB SHEET #5

b. Replace valve seats

1) Remove worn seat (Figure 11)

FIGURE 11

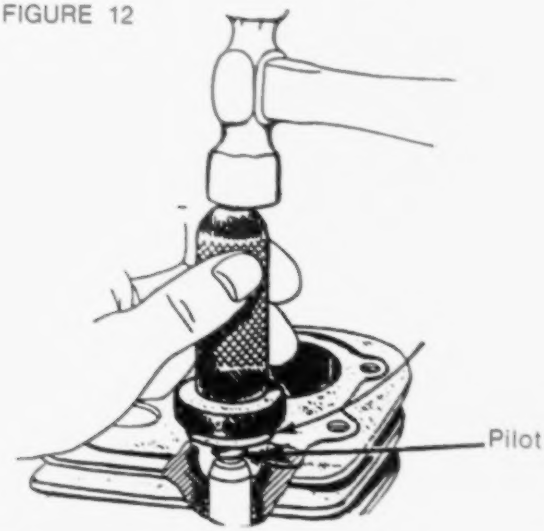

Body in Place
1/32"
(0.8 mm)
Valve Seat
Puller Nut
Exhaust
Valve
Insert

2) Place new seat in opening

(NOTE: It is often recommended that the new seat be chilled for at least one hour in a freezer.)

3) Install seat driving tool (Figure 12)

FIGURE 12



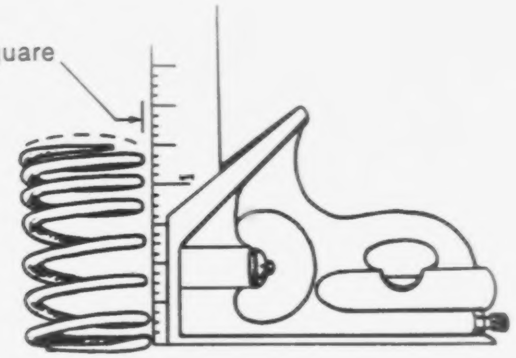
4) Tap tool to set new seat

5) Reface seat to recommended specifications

JOB SHEET #5

7. Inspect valve spring for squareness (Figure 13)

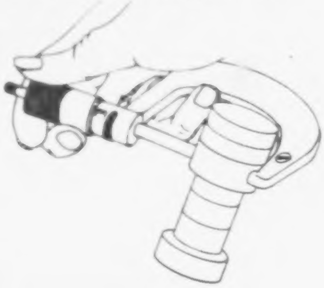
   FIGURE 13



8. Check crankshaft

   a. Measure bearing journals (Figure 14)

      FIGURE 14



   b. Measure inside bearing diameters

   c. Subtract bearing diameter from journals and compare to manufacturer's specifications

   d. Replace bearings if needed

   e. Measure cam lobe and compare to manufacturer's specifications

      (NOTE: Discard if tappet or push rod adjustment will not compensate for deterioration.)

   f. Check gear teeth

      (NOTE: Discard if teeth are damaged.)

JOB SHEET #5

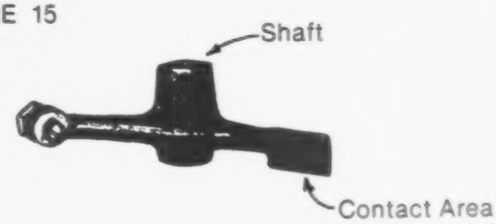
9. Check push rods (if applicable)
    a. Check for straightness

       (NOTE: Rolling them on a surface plate is a fairly accurate method.)

    b. Check for nicked or damaged ends

10. Check rocker arm assembly (if applicable)
    a. Check cam contact area
    b. Measure shaft bore with telescoping gauge and micrometer or dial indicator (Figure 15)

FIGURE 15



    c. Inspect rocker arm shaft (Figure 16)

       (NOTE: Look for pitted or rough areas.)

FIGURE 16

    d. Measure rocker arm shaft with micrometer
    e. Subtract rocker arm shaft reading from shaft bore reading
    f. Compare to manufacturer's specifications
    g. Repair if manufacturer's specifications are not met

       (NOTE: Repair usually involves driving out worn bushing and installing new. Consult appropriate service manual for exact procedure.)

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VIII-D

JOB SHEET #6 — REASSEMBLE A FOUR-STROKE CYCLE ENGINE

A. Tools and materials needed

1. Hand tool assortment
2. Gasket set for engines
3. Valve spring compressor
4. Ring compressor
5. Engine oil
6. Ring expander (feeler gauge)
7. Shop towels
8. Manual for engine
9. Plastigauge
10. Safety glasses

B. Procedure

1. Coat all metal surfaces with oil liberally before assembly
2. Install crankshaft in block

JOB SHEET #6

3. Assemble rod to piston with wrist pin (Figures 1 and 2)

   (Caution: Be sure new lock rings are in their groove in an upward position.)

FIGURE 1

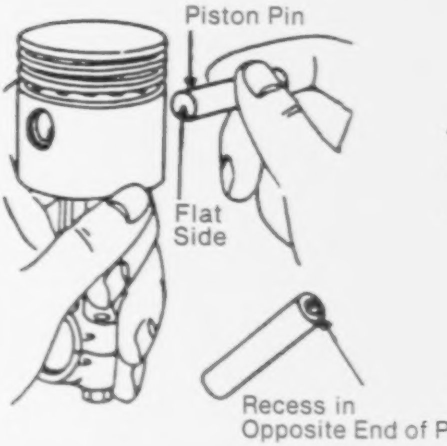
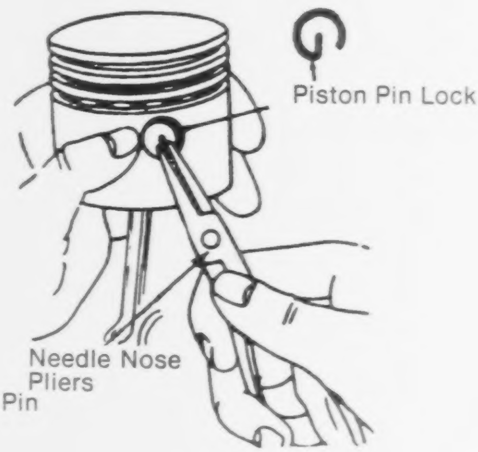
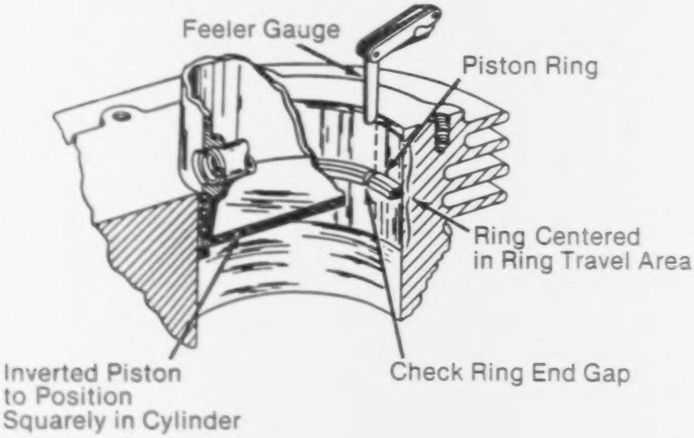

Piston Pin
Flat Side
Recess in Opposite End of Pin

FIGURE 2


Piston Pin Lock
Needle Nose Pliers

4. Check ring gap in cylinder
   a. Push ring into top of cylinder
   b. Align ring in cylinder with piston (Figure 3)

FIGURE 3


Feeler Gauge
Piston Ring
Ring Centered in Ring Travel Area
Check Ring End Gap
Inverted Piston to Position Squarely in Cylinder

JOB SHEET #6

c. Measure gap with feeler gauge

d. Compare to manufacturer's specification

(NOTE: Gap should be correct if cylinder was reconditioned in Job Sheet #2 and the correct rings are being used.)

5. Install ring or piston in correct position, using correct size ring expander and rotate rings approximately 90°(Figures 4 and 5)

FIGURE 4

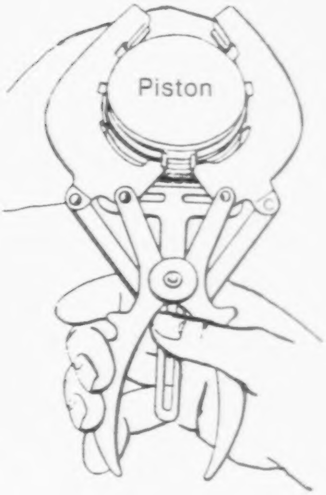
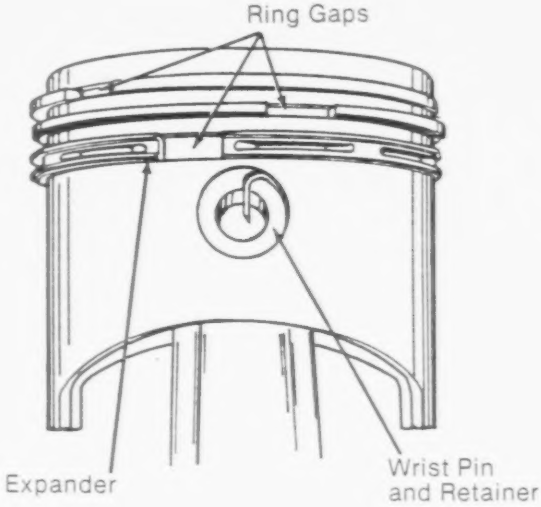


FIGURE 5

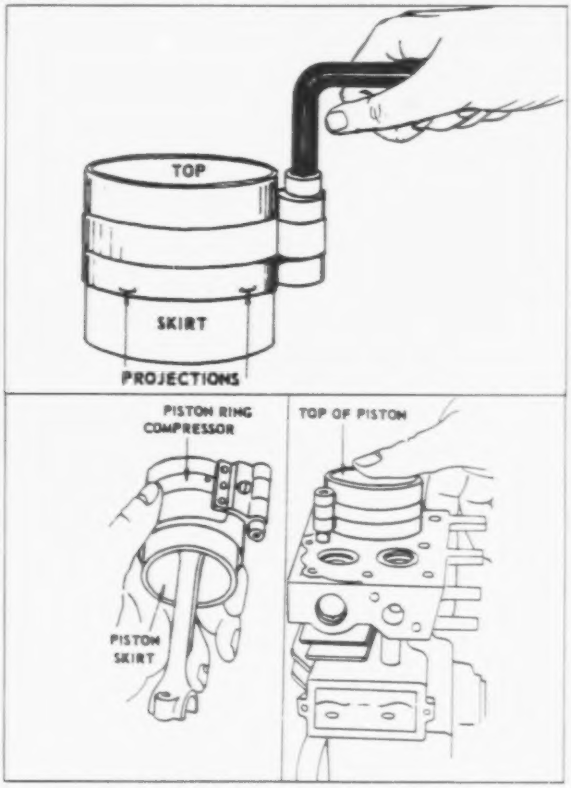

Ring Gaps
Expander
Wrist Pin
and Retainer

JOB SHEET #6

6. Install ring compressor on piston (Figure 6)

   (NOTE: A light coat of oil on the ring compressor and on the cylinder walls will make it easier to push the piston into the cylinder.)

   FIGURE 6


TOP
SKIRT
PROJECTIONS
PISTON RING COMPRESSOR
TOP OF PISTON
PISTON SKIRT

7. Push piston into cylinder using the handle of a hammer

   (Caution: Do not pound piston; broken rings may result.)

8. Line rod up in correct position on crankshaft

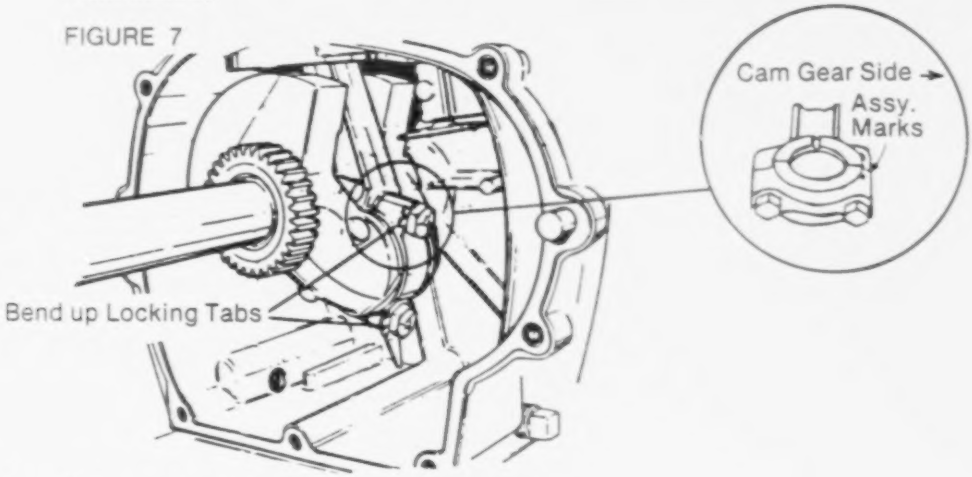
   (NOTE: A plastigauge test is often used during reinstallation of caps as a last check.)

JOB SHEET #6

9. Install rod cap, oil slinger, and lock tabs (Figure 7)

   (Caution: These must be in correct position or damage will result; check all alignment marks.)

   FIGURE 7


Cam Gear Side
Assy. Marks
Bend up Locking Tabs

10. Torque rod bolts to correct specifications

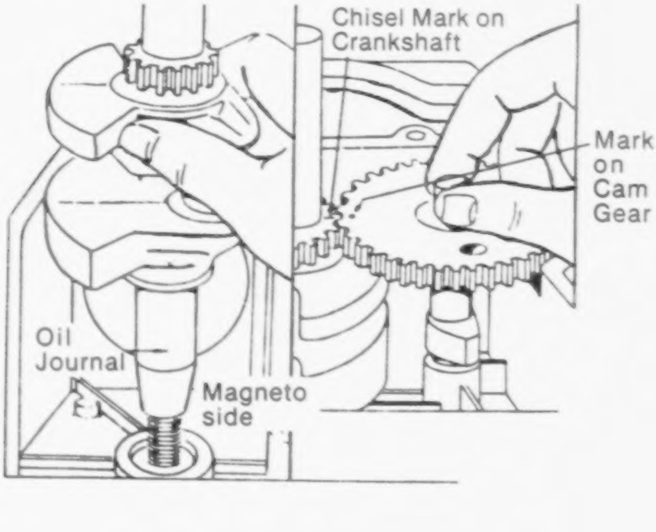
11. Install tappets

    (NOTE: They should be returned to the same location as when removed.)

12. Install camshaft and cam gear (Figure 8)

    (NOTE: Align cam gear and crankshaft timing gear marks.)

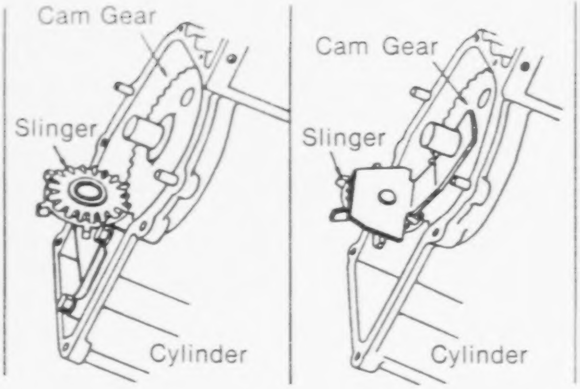
    FIGURE 8


Chisel Mark on Crankshaft
Mark on Cam Gear
Oil Journal
Magneto side

JOB SHEET #6

13. Install oil slinger or oil pump if engine is so equipped (Figure 9)

FIGURE 9


Cam Gear
Slinger
Cylinder
Cam Gear
Slinger
Cylinder

(NOTE: Some engines will have a spring washer on the end of the camshaft. Be sure this is in place.)

14. Install gasket on block assembly

(NOTE: Gaskets are different thicknesses to establish correct crankshaft end play on some engines.)

15. Install sump

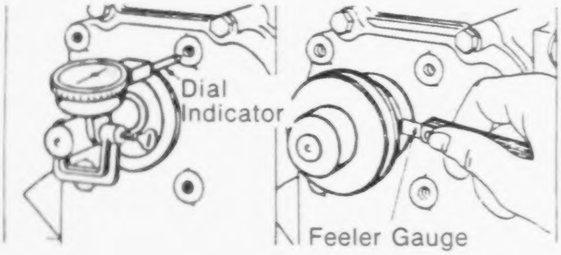
(Caution: Cover keyway with tape to prevent cutting oil seal.)

16. Torque sump bolts

17. Check end play of crankshaft (Figure 10)

(NOTE: It might be necessary to change gaskets or install shims to get correct end play. Consult appropriate service manual.)

FIGURE 10


Dial Indicator
Feeler Gauge

JOB SHEET #6

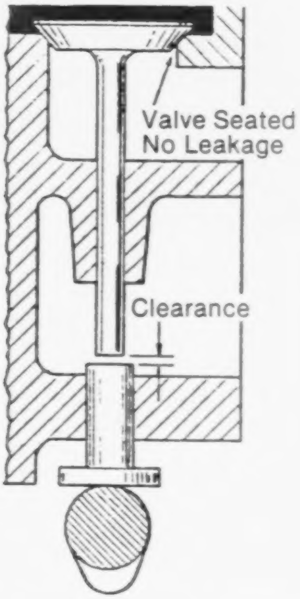
18. Install valves in correct position

(NOTE: Do not install springs or keepers.)

19. Check valves for correct clearance using a feeler gauge (Figure 11)

(NOTE: Grind the end of the valve stem off square for correct tappet to valve stem clearance, if there are no adjusting nuts.)

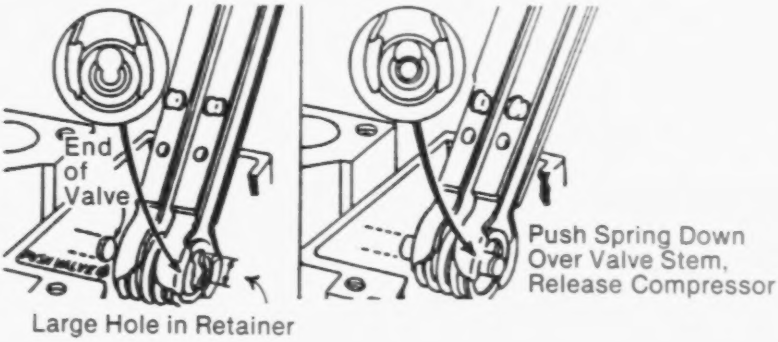
FIGURE 11


Valve Seated
No Leakage
Clearance

20. Install valve springs on correct valves (Figure 12)

(NOTE: Exhaust springs are usually stronger than intake springs. Be sure valve spring washer and keeper are positioned correctly.)

FIGURE 12


End
of
Valve
Large Hole in Retainer
Push Spring Down
Over Valve Stem,
Release Compressor

JOB SHEET #6

21. Install valve cover and valve cover gasket

22. Install air deflector shields

23. Install cam plunger, ignition points, and condenser

24. Gap points to correct setting when points are fully open

    (NOTE: Coil and ignition switch wires should be correctly attached to condenser post.)

25. Install point dust cover

    (NOTE: Sealer should be in place where ignition and coil wire enter.)

26. Install flywheel and flywheel key, washer and starter recoil mechanism

    (NOTE: Torque flywheel nut to correct specifications.)

    (Caution: Be sure to install washer correctly.)

27. Install coil assembly setting correct air gap to flywheel clearance

    (NOTE: Time coil assembly to flywheel if it is adjustable.)

28. Install air vane governor assembly

    (NOTE: This might have to be installed along with coil assembly.)

29. Check cylinder head for warpage

30. Install cylinder headgasket, cylinder head, and air deflector

    (NOTE: Place bolts in correct position, tighten in correct sequence and to correct torque.)

31. Install shroud and flywheel cover and fuel tank

32. Install carburetor gasket, carburetor and governor linkage, and springs

33. Connect fuel lines and valve cover breather tube

34. Install muffler and locknut

35. Install engine on equipment or implement

36. Connect remote throttle, belts, and other equipment

37. Fill crankcase with new oil

JOB SHEET #6

38. Install serviced air filter on carburetor
39. Fill fuel tank with fresh fuel
40. Install spark plug
41. Turn on fuel to carburetor
42. Make final adjustments
43. Implement safety procedures
44. Have instructor evaluate work

    (NOTE: Start engine only after getting instructor's permission.)

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VIII-D

NAME ______________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. To restore to manufacturer's specifications

_____b. Wearing or rubbing away

_____c. Bearing constructed with balls or rollers between journal and bearing surface to provide rolling instead of sliding friction

_____d. Alloy of tin, copper, lead, silver, and antimony having good anti-friction properties; used as a facing bearings

_____e. Clearance or "play" between two parts

_____f. Leakage or loss of pressure

_____g. Process of wearing into a desirable fit new or reconditioned parts

_____h. Removable sleeve used as a bearing

_____i. Shaft containing lobes or cams which operate engine valves

_____j. Common nonmetallic element which forms in combustion chamber of an engine during burning of fuel and lubricating oil

_____k. Space allowed between two parts

_____l. Series of weights attached to or forged integrally with the crankshaft, placed so as to offset the reciprocating weight of each piston and rod assembly

_____m. Piston pin which is not locked in the connecting rod or the piston, but is free to turn or oscillate in both the connecting rod and the piston

1. Bushing
2. Babbit
3. Camshaft
4. Valve seat
5. Valve grinding
6. Press fit
7. Gasket
8. Valve stem
9. Journal
10. Abrasion
11. Valve lapping
12. Carbon
13. Crankshaft counterbalance

TEST

______n. Substance placed between two metal surfaces to act as a seal

______o. Abrasive tool for deglazing and correcting irregularities or differences in diameter in cylinder

______p. Difference in angle between mating surfaces of a valve and a valve seat

______q. Part of a shaft or crank which rotates inside a bearing

______r. Term used to describe an engine which is using an excessive amount of lubricating oil

______s. Rocking of loose fitting piston in a cylinder, making a hollow bell-like sound

______t. Known as a force fit or drive fit

______u. Sufficient clearance has been allowed between the shaft and journal to allow free running without overheating

______v. One surface adhering to another because of heat and pressure

______w. Exceptionally tight fit achieved by heating and/or cooling of parts

______x. Process of mating the valve seat and valve face

______y. Process of refacing the valve and seat to manufacturer's specifications

______z. Angle surface of valve which mates with the seat to seal the chamber

______aa. Top of the large diametered valve end

______bb. Space between valve face and head

14. Valve clearance
15. Shrink fit
16. Valve margin
17. Running fit
18. Hone
19. Valve face
20. Backlash
21. Valve head
22. Blow-by
23. Overhaul
24. Seize
25. Piston slap
26. Oil pumping
27. Interference angle
28. Anti-friction bearing

TEST

_____cc. Long portion of valve which rests within the valve guide

_____dd. Angle surface in engine block or head which provides mating surface for valve face

_____ee. Distance between valve stem and tappet at lowest tappet position

29. Break in
30. Floating piston pin
31. Clearance

2. List five causes of engine problems.

a. ____________________

b. ____________________

c. ____________________

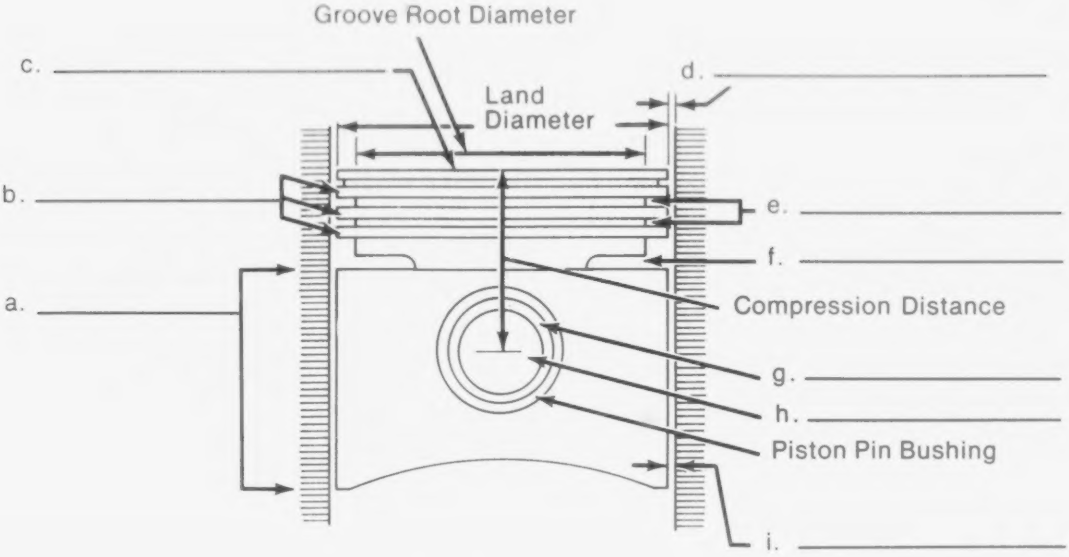
d. ____________________

e. ____________________

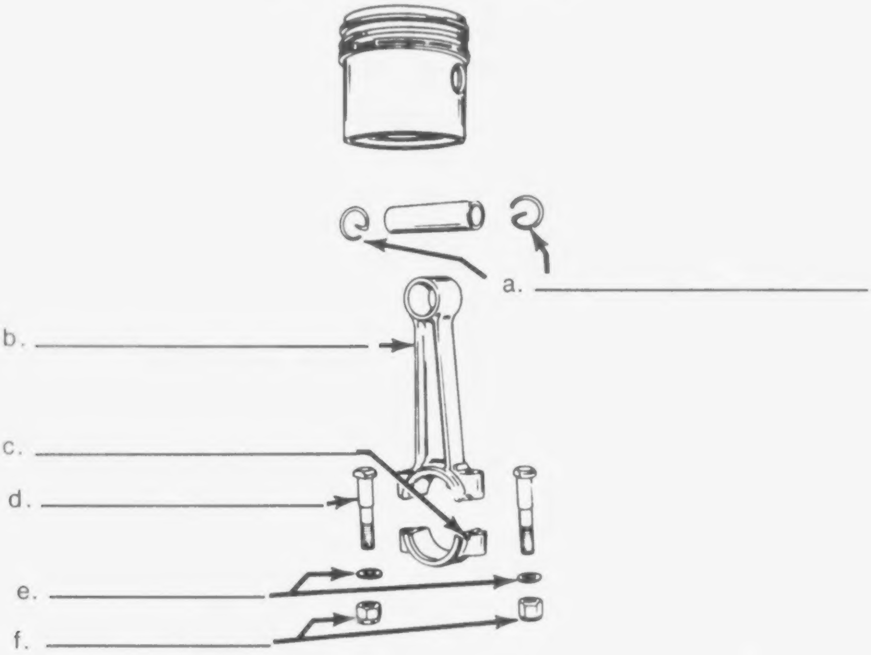
TEST

3. Identify the parts of the piston and connecting rod assembly.

Piston Assembly

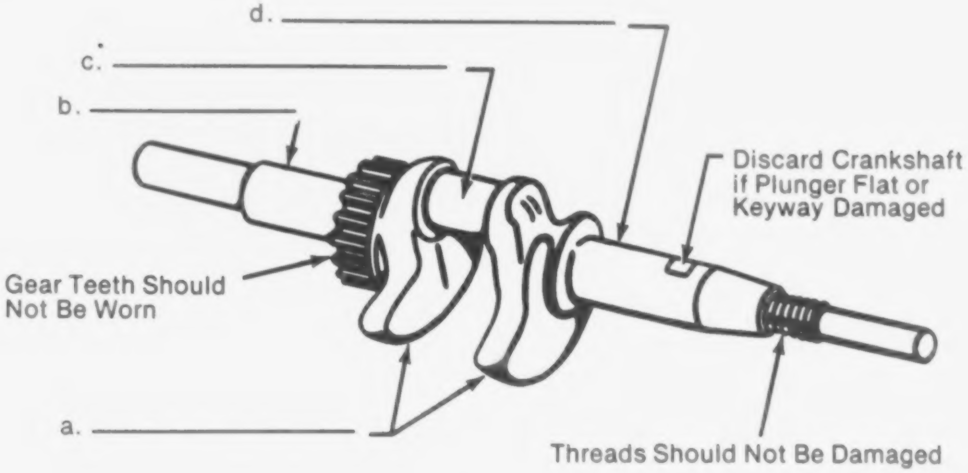

Groove Root Diameter
c. ________
d. ________
Land Diameter
b. ________
e. ________
f. ________
a. ________
Compression Distance
g. ________
h. ________
Piston Pin Bushing
i. ________

Connecting Rod Assembly

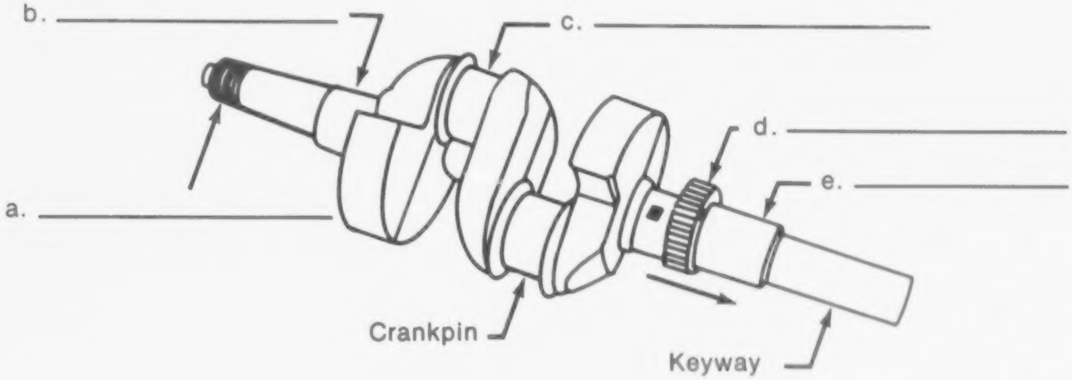


TEST

4. Identify the parts of the crankshaft assembly.

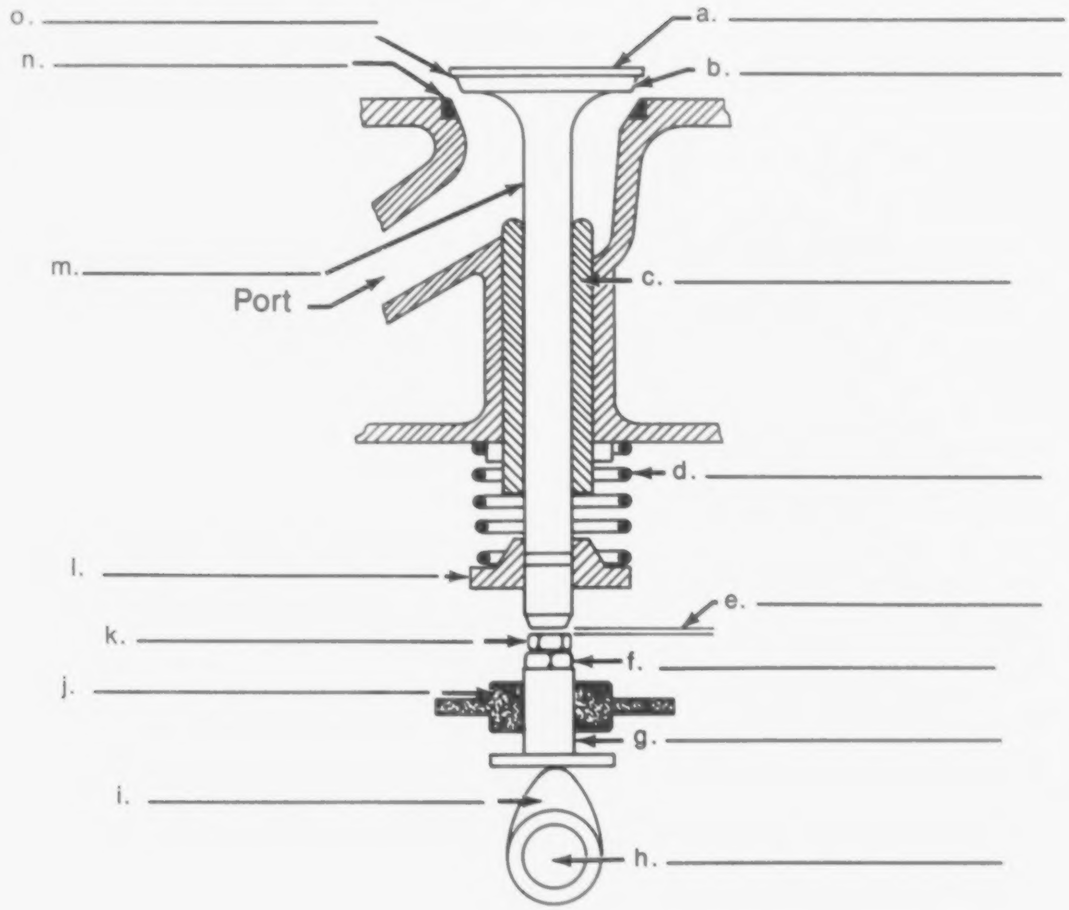

d.
c.
b.
Discard Crankshaft if Plunger Flat or Keyway Damaged
Gear Teeth Should Not Be Worn
a.
Threads Should Not Be Damaged

5. Identify the parts of the multi-piece crankshaft.


b.
c.
d.
e.
a.
Crankpin
Keyway

TEST

6. Identify the parts of the valve train.



(NOTE: If the following activities have not been accomplished prior to the test, ask you instructor when they should be completed.)

7. Demonstrate the ability to:

   a. Disassemble a four-stroke cycle engine (Job Sheet #1).

   b. Inspect and service a cylinder (Job Sheet #2).

   c. Inspect and service the piston, rings, and connecting rod (Job Sheet #3).

TEST

d. Inspect and service a crankshaft and crankcase assembly (Job Sheet #4).

e. Inspect and service a valve assembly (Job Sheet #5).

f. Reassemble a four-stroke cycle engine (Job Sheet #6).

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VIII-D

ANSWERS TO TEST

1.

a.	23	m.	30	y.	5
b.	10	n.	7	z.	19
c.	28	o.	18	aa.	21
d.	2	p.	27	bb.	16
e.	20	q.	9	cc.	8
f.	22	r.	26	dd.	4
g.	29	s.	25	ee.	14
h.	1	t.	6		
i.	3	u.	17		
j.	12	v.	24		
k.	31	w.	15		
l.	13	x.	11		

2. a. Allowing dirt to get into the engine
   b. Failure to check crankcase oil level often enough and letting engine run low on oil
   c. Overloading the engine so that it works too hard
   d. Running the engine too fast
   e. Failure to properly store the engine during the off season

3. Piston and rod assembly
   a. Skirt
   b. Land
   c. Piston head
   d. Ring side clearance
   e. Compression and scraper ring groove
   f. Oil ring groove
   g. Piston pin (wrist pin)
   h. Pin hole
   i. Thrust face clearance

   Connecting rod assembly
   a. Retaining ring
   b. Connecting rod
   c. Bearing cap
   d. Connecting rod bolts
   e. Washer
   f. Self-locking nut

4. a. Counterweights
   b. Journal P.T.O. end
   c. Journal crankpin
   d. Journal magneto end

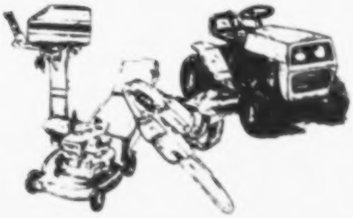
5. a. Threads and keyway
   b. Mag journal
   c. Crankpin

ANSWERS TO TEST

- d. Gearteeth and keyway
- e. P.T.O. journal

6. a. Head
   b. Face
   c. Valve guide
   d. Valve spring
   e. Clearance
   f. Locknut
   g. Tappet
   h. Shaft
   i. Cam
   j. Tappet guide
   k. Adjusting nut
   l. Retainer
   m. Stem
   n. Seat
   o. Margin

7. Performance skills evaluated according to the standards identified by the instructor



Overhaul Two-Stroke Cycle Engine
Unit IX-D

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify parts of a two-stroke cycle engine and disassemble, inspect, service, and reassemble a two-stroke cycle engine. Competencies will be demonstrated by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to the overhaul of two-stroke cycle engines with their correct definitions.
2. List causes of two-stroke cycle engine problems.
3. Identify the parts of the two-stroke cycle piston and connecting rod assembly.
4. Identify the parts of a two-stroke cycle crankshaft assembly.
5. Demonstrate the ability to:
    a. Disassemble, inspect, and service a two-stroke cycle engine (Job Sheet #1).
    b. Reassemble a two-stroke cycle engine (Job Sheet #2).

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT IX-D

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to supplement/reinforce information provided in unit of instruction.

(NOTE: This step should be completed prior to the teaching of this unit.)

B. Make transparencies.

(NOTE: A set of acetate transparencies is available for this publication. For additional information, write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074, or call (405) 377-2000, or toll-free 1-800-654-3988 [except in Oklahoma, Hawaii, or Alaska].)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss the information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets prior to the demonstration of the procedures.

H. Integrate the following activities throughout the teaching of this unit:

1. Provide live examples of pistons, connecting rod assemblies, and crankshaft assemblies.
2. Compare overhaul of the two-stroke cycle engine with the overhaul of the four-stroke cycle engine.
3. Show difference between integral type and multi-piece type crankshaft.
4. Demonstrate and discuss the procedures outlined in the job sheets.
5. Assist students in evaluation of their completed units of instruction and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

SUGGESTED ACTIVITIES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

   1. TM 1 — Parts of Piston and Connecting Rod Assembly
   2. TM 2 — Parts of Crankshaft Assembly

E. Job Sheets

   1. Job Sheet #1 — Disassemble, Inspect, and Service a Two-Stroke Cycle Engine
   2. Job Sheet #2 — Reassemble a Two-Stroke Cycle Engine

F. Test

G. Answers to test

REFERENCES USED IN DEVELOPING THIS UNIT

A. *Comprehensive Small Engine Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1977.

B. *Chilton's Motorcyle Repair Manual.* Radnor, Pennsylvania: Chilton's Motor Co., 1975.

C. *Chilton's Yamaha Repair and Tune-Up Guide.* Radnor, Pennsylvania: Chilton's Motor Co., 1973.

D. *Harley-Davidson Service Manual: Sportster XL/XLH/XLCH, 1970 to 1973.* Harley-Davidson Motor Co., Inc., 1972.

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT IX-D

INFORMATION SHEET

I. **Terms and definitions**

   A. Abrasion — Wearing or rubbing away

   B. Anti-friction bearing — Bearing constructed with balls or roller between journal and bearing surface to provide rolling instead of sliding friction

   C. Blow-by — A leakage or loss of pressure, often used with reference to leakage of compression past piston ring between piston and cylinder

   D. Carbon — Common nonmetallic element which forms in combustion chambers of an engine during burning of fuel and oil mixture

   E. Two cycle oil — Oil specifically formulated to be added to gasoline and used in two-stroke cycle engines

   F. Crankcase leakage — Inadequate sealing between housing, crankcase, or reed plate

II. **Causes of two-stroke cycle engine problems**

   A. Incorrect ratio of two cycle oil mixed with fuel

   B. Incorrect type of oil mixed with fuel

   (NOTE: Do not mix mineral base oils with synthetic oils.)

   C. Allowing dirt to get into engine

   D. Improper engine speed

   E. Failure to properly store the engine during the off season

   F. Overheating of engine

   G. Clogging of exhaust

III. **Parts of piston and connecting rod assembly** (Transparency 1)

   A. Land

   B. Ring groove

   C. Ring groove pin

INFORMATION SHEET

D. Connecting rod

E. Needle bearings

F. Rod cap

G. Cap screws

H. Match marks

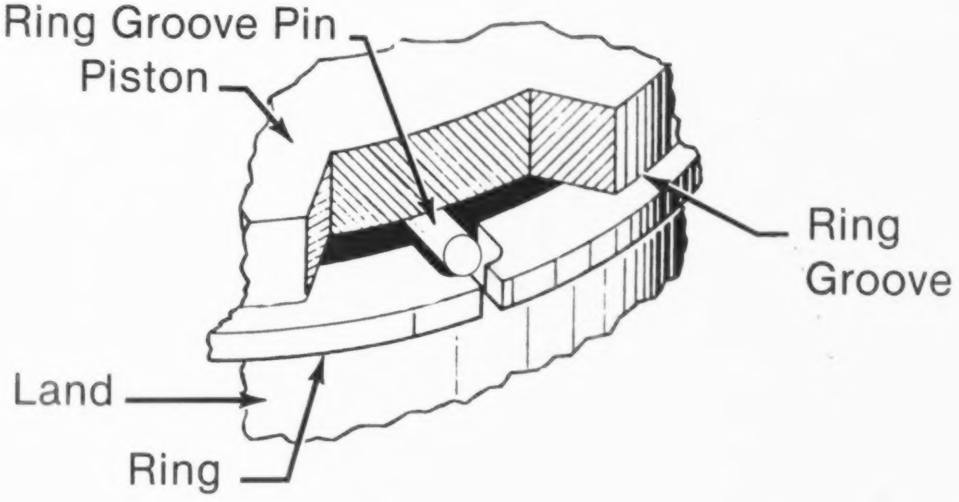
IV. **Parts of the two-cycle crankshaft assembly** (Transparency 2)

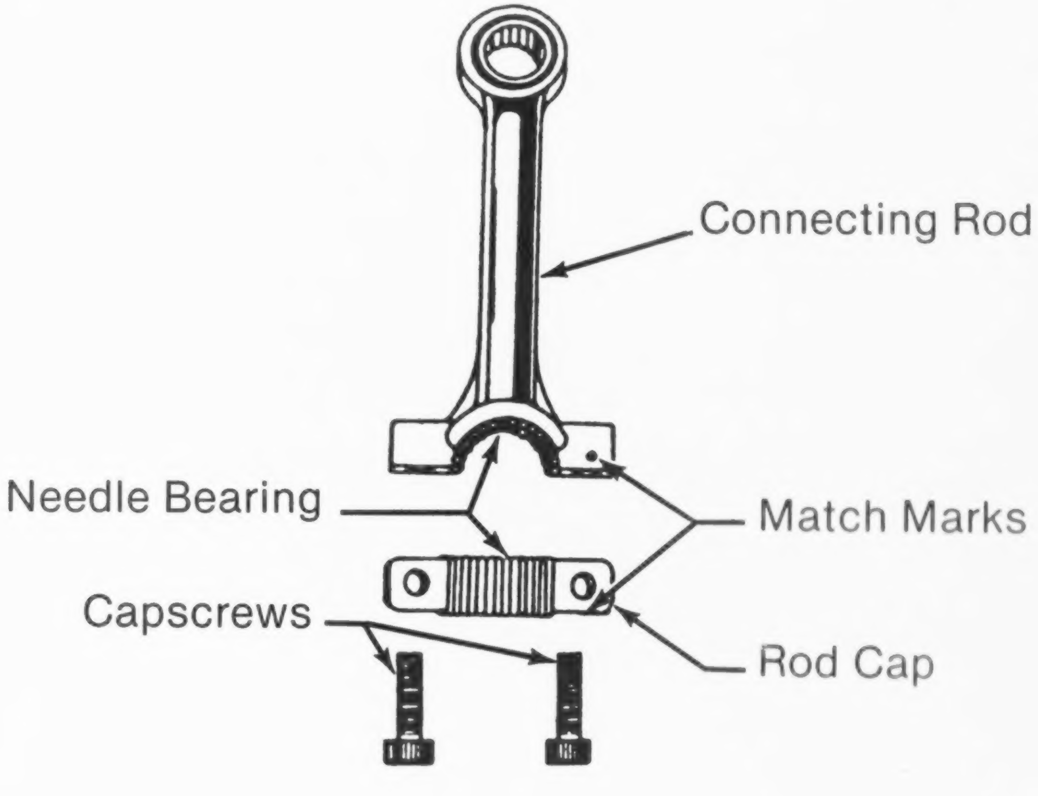
A. Main bearing journals

B. Crankpin (connecting rod bearing journal)

C. Counterweights

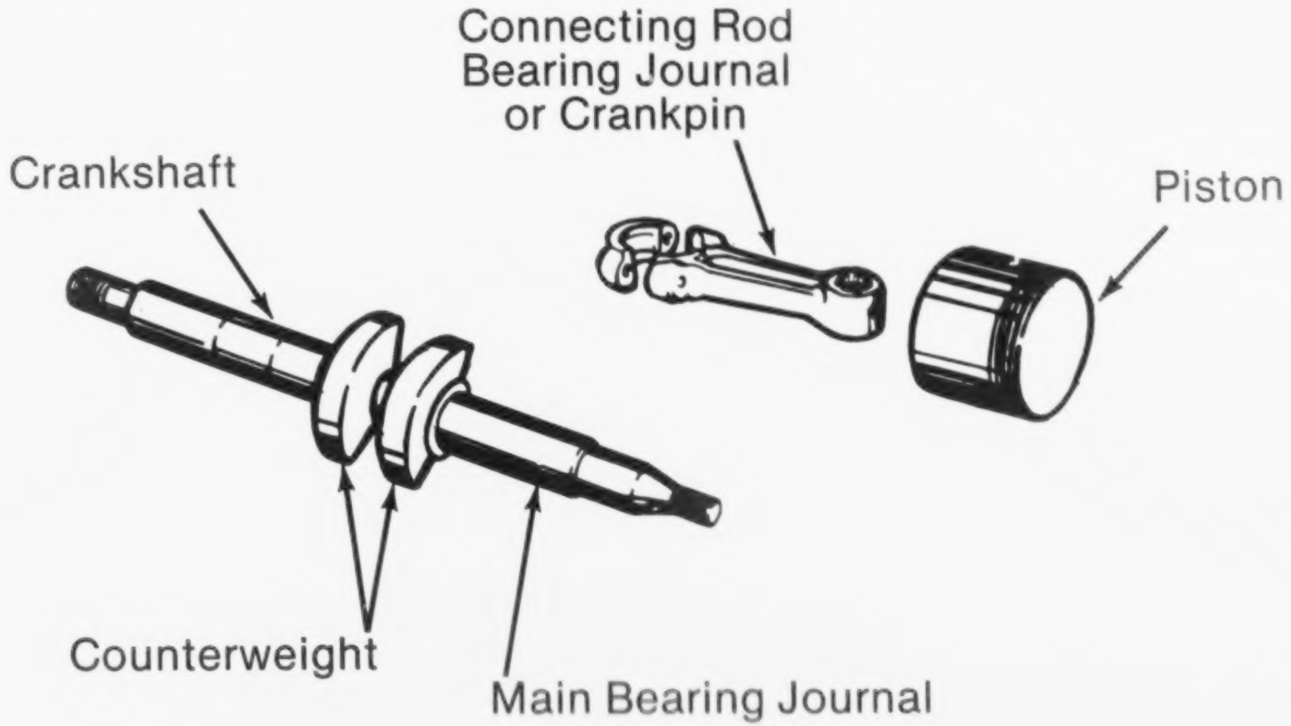
Parts of Piston and Connecting Rod Assembly


Ring Groove Pin
Piston
Ring Groove
Land
Ring


Connecting Rod
Needle Bearing
Match Marks
Capscrews
Rod Cap

Parts of Crankshaft Assembly

(2-Cycle)


Connecting Rod Bearing Journal or Crankpin
Crankshaft
Piston
Counterweight
Main Bearing Journal

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT IX-D

JOB SHEET #1 — DISASSEMBLE, INSPECT, AND SERVICE A TWO-STROKE CYCLE ENGINE

A. Tools and materials needed

1. Hand tool assortment
2. Piston stop
3. Soft headed hammer
4. Special tools as needed for engine
5. Engine stand
6. Shop towels
7. Cleaning solvent
8. Engine manufacturer's shop manual
9. New oil seals
10. Deglazing tool
11. Safety glasses

B. Procedure

1. Disconnect high tension lead(s)
2. Remove engine shroud or cover
3. Disconnect battery leads to starter
4. Disconnect external fuel lines
5. Disconnect external throttle, shift, and clutch control cables attached to engine assembly
6. Remove engine from assembly

   (NOTE: On large outboards the lower unit can remain attached to the boat; on smaller outboards it is often easiest to remove the outboard from the boat and remove the engine on a work bench.)

JOB SHEET #1

7. Mount engine on suitable stand

   (NOTE: Some engines are quite heavy and should be lifted with a winch or with assistance of other mechanics.)

8. Remove spark plug(s)

9. Remove flywheel

   (NOTE: Refer to appropriate service manual for specific pullers and procedures.)

10. Check flywheel for broken cooling fins, damaged gear teeth, magnet strength, and damaged keyways

    (NOTE: As a general rule if you place a 1/2" socket on the magnet and can shake the flywheel without it falling off, the magnets have sufficient strength.)

11. Remove air baffles

12. Remove armature plate

13. Remove flywheel key

    (NOTE: Roll the key out of the groove.)

14. Remove governor assembly from crankshaft

    (NOTE: Sketch the linkage for reassembly.)

15. Remove dust cover

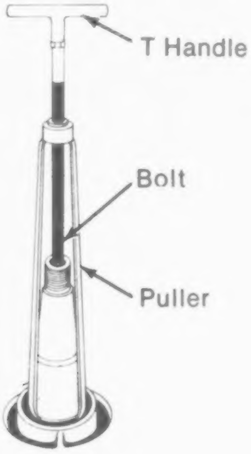
16. Remove spark advance mechanism

17. Remove magneto plate assembly

    (NOTE: On some engines, crankshaft main needle bearings must be held in place to prevent them from falling out.)

18. Remove oil seal from armature plate (Figure 1)

    FIGURE 1



JOB SHEET #1

19. Remove armature plate bearing (Figures 2 and 3)

(NOTE: It often helps to heat casing before removing bearings.)

FIGURE 2

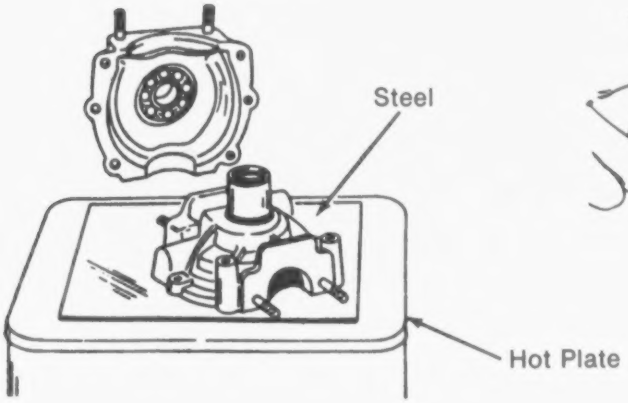
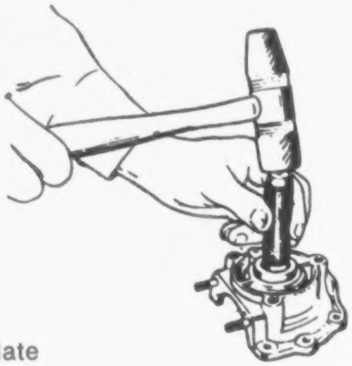

Steel
Hot Plate

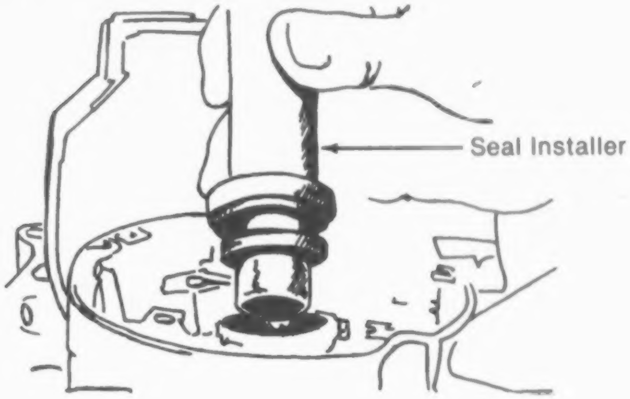
FIGURE 3



20. Install new oil seal (Figure 4)

(NOTE: Refer to appropriate service manual for specific tools and directions.)

FIGURE 4

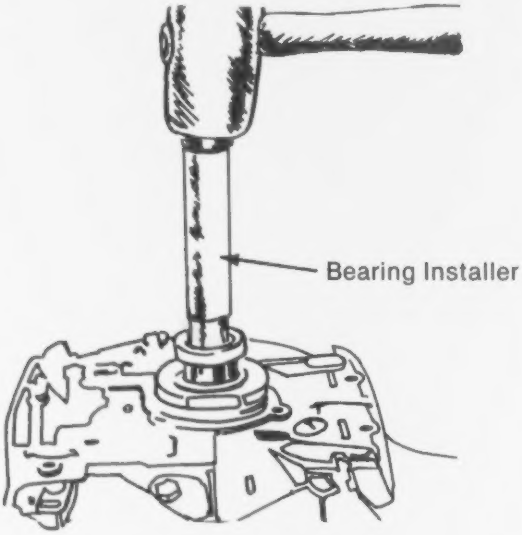

Seal Installer

JOB SHEET #1

21. Replace worn bearings in armature plate (Figure 5)

(NOTE: Refer to appropriate service manual.)

FIGURE 5



22. Remove carburetor and reed plate assembly
23. Remove cylinder or cylinder head
24. Remove rod caps
25. Remove piston assembly

(NOTE: Use care when removing connecting rods using loose needle bearings. Don't lose them and be sure they are all in good condition. Replace as necessary.)

(CAUTION: Do not lift with magnets.)

26. Remove wrist pin retaining rings and drive out pin

(NOTE: Count needle bearings and be careful not to lose any of them.)

27. Remove crankshaft from crankcase oil seal (oil seal is not supporting crankshaft)
28. Remove crankcase oil seal
29. Remove, inspect, and replace crankcase bearings as needed
30. Measure crankshaft journals and pin

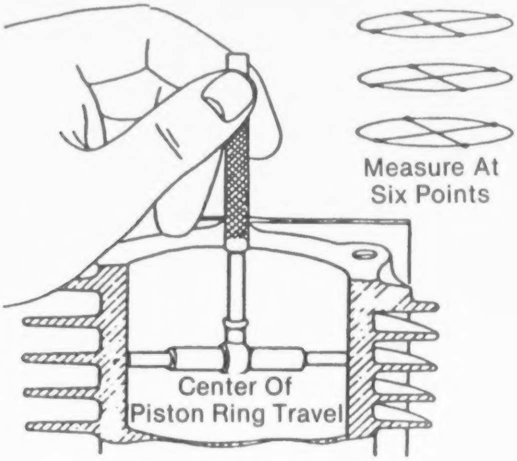
(NOTE: Compare to manufacturer's specifications; repair or replace as necessary.)

JOB SHEET #1

31. Measure cylinder at top, center, and bottom (Figure 6)

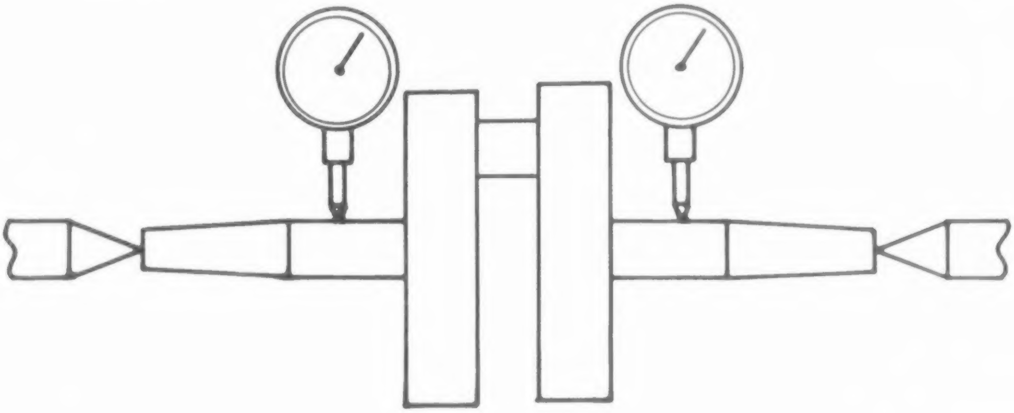
    (NOTE: Compare to manufacturer's specifications; repair or replace as necessary.)

    FIGURE 6


Measure At
Six Points
Center Of
Piston Ring Travel

32. Measure crankshaft runout (Figure 7)

    FIGURE 7



JOB SHEET #1

33. Inspect piston

    a. Measure pin bosses

    b. Measure skirt

    c. Check and scrape ring

    (NOTE: Compare these readings to manufacturer's specifications. Replace as required.)

    d. Check ring end gap at bottom of ring travel

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT IX-D

JOB SHEET #2 — REASSEMBLE TWO-STROKE CYCLE ENGINE

A. Tools and materials needed

1. Hand tool assortment
2. Piston stop
3. Special tool for engine reassembly
4. Piston ring compressor
5. Engine oil
6. New gasket set
7. Shop towels
8. Engine stand
9. Safety glasses

B. Procedure

1. Install crankshaft in crankcase

   (NOTE: All metal to metal surfaces should be coated with 2 cycle oil.)

   (CAUTION: Do not damage oil seal when installing crankshaft.)

2. Drive wrist pin through piston and connecting rod

   (NOTE: Install connecting rod on piston so as not to damage needle bearing.)

3. Install wrist pin retainer rings

   (NOTE: They must be installed facing upward or they will pop out during operation.)

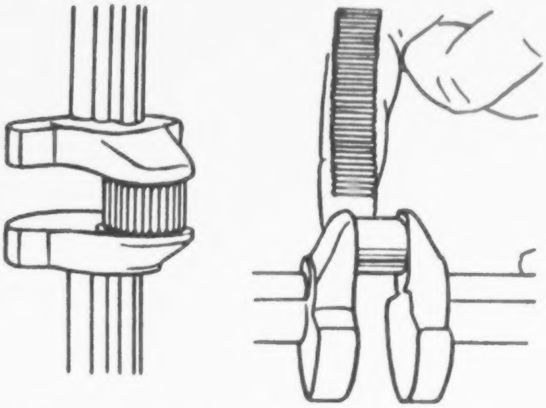
4. Place strip of needle bearings on crankshaft (Figure 1)

   (NOTE: If old needles are to be reinstalled coat them in petroleum jelly or a suitable lubricant so they will adhere to rod and cap.)

JOB SHEET #2

(CAUTION: Correct number of needle bearings must be installed on rod and cap; check this carefully.)

FIGURE 1



5. Install rod with aligned match marks on crankshaft journal and install rod cap

   (NOTE: Tighten rod cap bolts finger tight, just enough to hold needle bearings in place.)

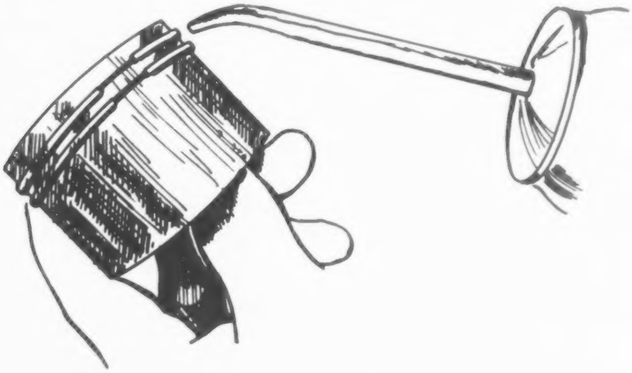
   (CAUTION: Piston will have a mark to identify the top location; this must be installed up.)

6. Install cylinder to crankcase gasket in correct location

7. Install ring compressor over head of piston and compressor rings

   (NOTE: Rings should be coated with oil. See Figure 2.)

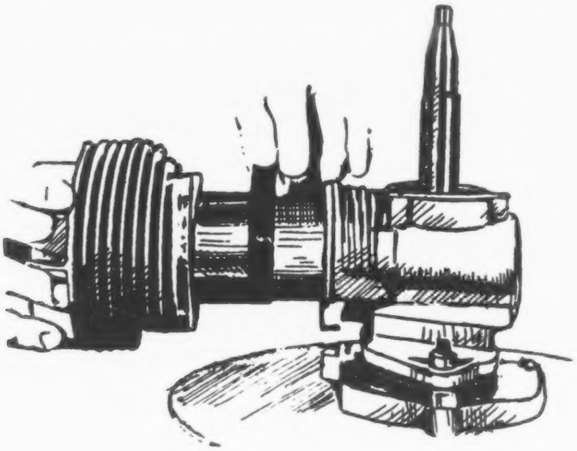
FIGURE 2



JOB SHEET #2

8. Maintain pressure on rings and slide rings into cylinder (Figure 3)

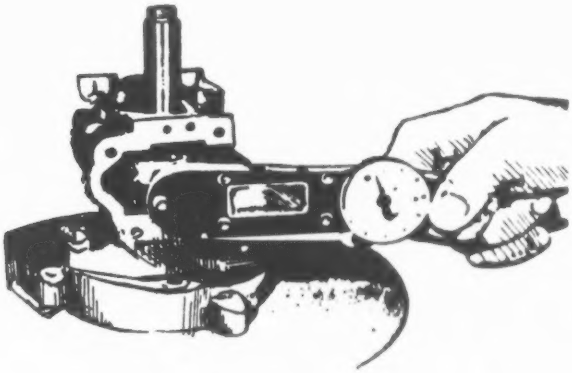
FIGURE 3



9. Center rod on wrist pin

10. Torque rod capscrews to correct torque (Figure 4)

FIGURE 4

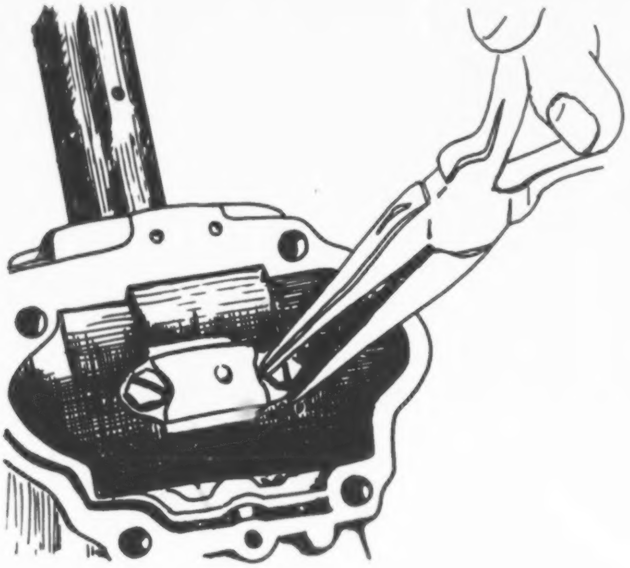


JOB SHEET #2

11. Bend lock tabs to retain rod capscrews (Figure 5)

    (NOTE: Use new tabs as necessary.)

    FIGURE 5



12. Torque cylinder to crankcase bolts

    (NOTE: Check to be sure washers are located in correct position as some bolts do not have washers.)

13. Install reed plate and carburetor on engine

    (NOTE: Locate gasket correctly on crankcase.)

14. Install armature plate on crankcase using correct gasket to have correct crankshaft end play

    (NOTE: Properly protect seal and main bearings when installing armature plate.)

15. Tighten armature to crankcase screws

16. Check ignition point gap

17. Install flyweight on crankshaft

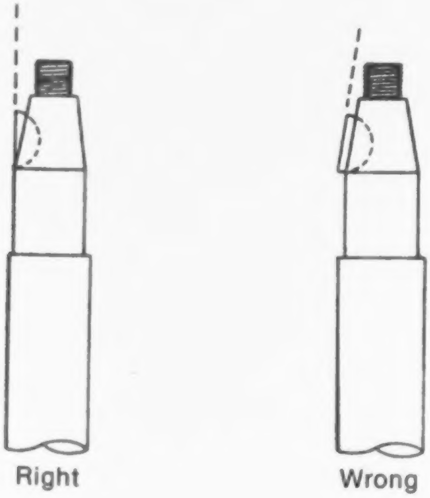
    (NOTE: Install in correct location with crankshaft keyway.)

JOB SHEET #2

18. Install dust cover
19. Install governor assembly
20. Install flywheel and torque flywheel nut to correct torque

    (NOTE: Flywheel key must be installed correctly. See Figure 6.)

    FIGURE 6



Make Sure Key Is Installed Correctly

21. Install air baffles, governor linkage, starter connections, and shroud, and make fuel connections
22. Install spark plug
23. Install spark plug high tension wire
24. Place correct fuel and two cycle oil mixture in fuel tank
25. Mount engine to implement
26. Make final adjustments
27. Check with instructor and start engine

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT IX-D

NAME ____________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Oil specifically formulated to be added to gasoline and used in two-stroke cycle engines

_____b. Wearing or rubbing away

_____c. Inadequate sealing between housing, crankcase, or reed plate

_____d. Bearing constructed with balls or rollers between journal and bearing surface to provide rolling instead of sliding friction

_____e. A leakage or loss of pressure often used with reference to leakage of compression past piston ring between piston and cylinder

_____f. Common nonmetallic element which forms in combustion chambers of an engine during burning of fuel and oil mixture

1. Blow-by
2. Crankcase leakage
3. Two cycle oil
4. Abrasion
5. Anti-friction bearing
6. Carbon

2. List five causes of two-stroke cycle engine problems.

a. ______________________________

b. ______________________________

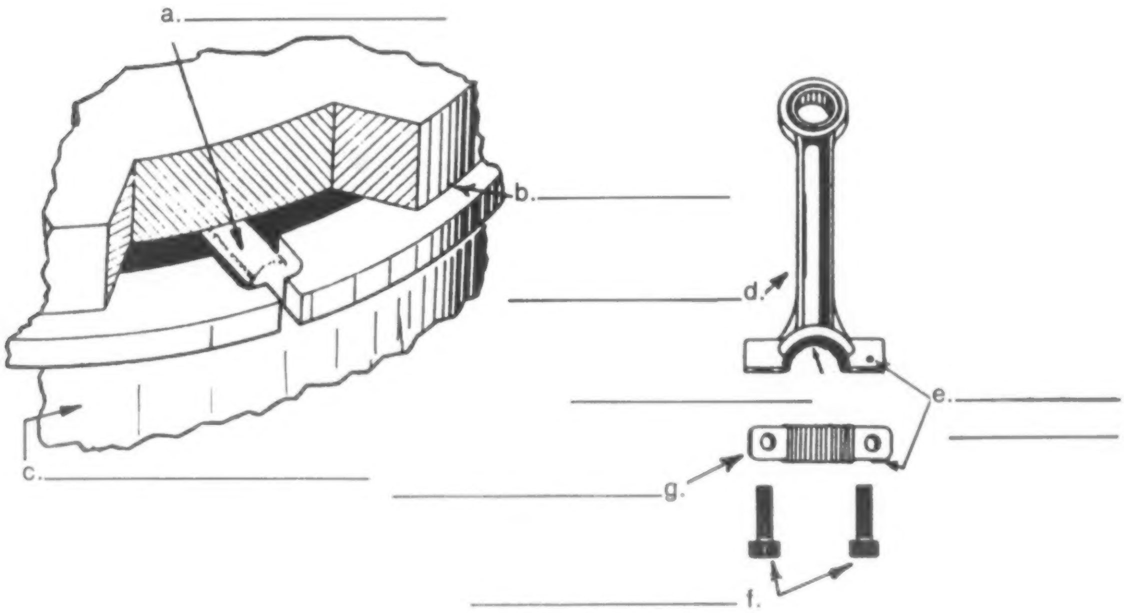
c. ______________________________

d. ______________________________

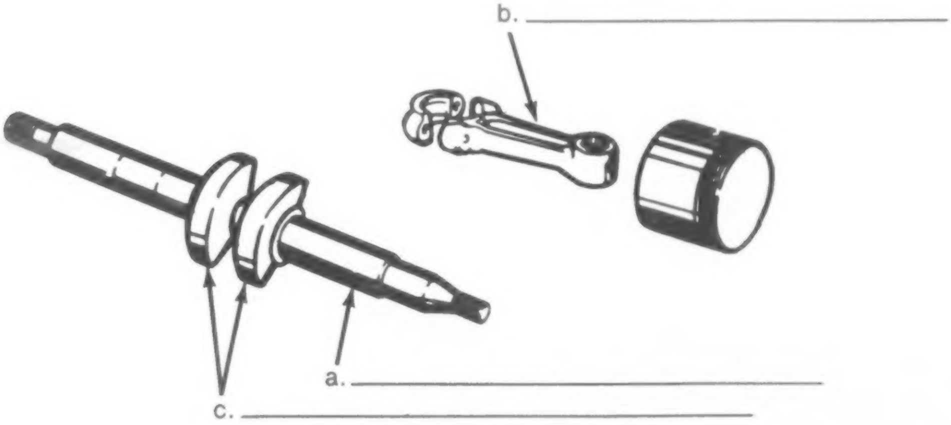
e. ______________________________

TEST

3. Identify the parts of the two-stroke cycle piston and connecting rod assembly.



4. Identify the parts of a two-stroke cycle crankshaft assembly.



TEST

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

5. Demonstrate the ability to:

   a. Disassemble, inspect, and service a two-stroke cycle engine (Job Sheet #1).

   b. Reassemble a two-stroke cycle engine (Job Sheet #2).

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT IX-D

ANSWERS TO TEST

1. a. 3
   b. 4
   c. 2
   d. 5
   e. 1
   f. 6

2. Any five of the following:
   a. Incorrect ratio of two cycle oil mixed with fuel
   b. Incorrect type of oil mixed with fuel
   c. Allowing dirt to get into engine
   d. Improper engine speed
   e. Failure to properly store the engine during the off season
   f. Overheating of engine
   g. Clogging of exhaust

3. a. Ring
   b. Land
   c. Piston
   d. Ring groove pin
   e. Ring groove
   f. Connecting rod
   g. Match marks
   h. Rod cap
   i. Capscrews
   j. Needle bearing

4. a. Main bearing journal
   b. Crankpin (connecting rod bearing journal)
   c. Counterweights

5. Performance skills evaluated according to the standards identified by the instructor

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THANK YOU.

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I would suggest that to improve the materials, MAVCC should

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